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DEPARTMENT OF THE ARMY FIELD MANUAL

FIELD ARTILLERY
HONEST JOHN / LITTLE JOHN
ROCKET GUNNERY

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HEADQUARTERS, DEPARTMENT OF THE ARMY

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FIELD MANUAL
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HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *9 September 1964*

FIELD ARTILLERY
HONEST JOHN/LITTLE JOHN
ROCKET GUNNERY

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* This manual supersedes Chapter 10 (para. 53–76), FM 6–56, 3 August 1961; and so much of C 2, FM 6–61, 30 January 1962, as pertains to Chapter 11 (para. 60–84).

CHAPTER 1
INTRODUCTION

Section 1. GENERAL

1. Purpose

This manual explains the field artillery HONEST JOHN/LITTLE JOHN gunnery problem and presents a practical solution to that problem. It is a guide for HONEST JOHN/LITTLE JOHN unit commanders and members of their staff on field artillery rocket gunnery.

2. Scope

This manual encompasses all aspects of the gunnery problem from the time that the rocket is issued from the special ammunition supply point (SASP) until it is fired. The material presented herein is applicable to both nuclear and nonnuclear warfare. The scope includes—

a. Fundamentals of rocket ballistics.

b. Fire direction.

c. Miscellaneous gunnery information.

3. Changes or Corrections

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commandant, U.S. Army Artillery and Missile School, ATTN: AKPSIPL, Fort Sill, Oklahoma.

4. References

See appendix I for list of references.

Section II. BALLISTICS

5. General

The study of ballistics pertaining to cannon is usually divided into internal and external ballistics. In order to provide a background for understanding the complete HONEST JOHN/LITTLE JOHN gunnery problem, the following discussion is based on a similar division. The effects on that portion of flight prior to burnout of the rocket motor will be referred to as propulsion ballistics. The period of flight after burnout will be referred to as free-flight ballistics.

6. Propulsion Ballistics

Atmospheric conditions have considerable effect on a rocket during powered flight.

a. Variations in Thrust. Variations in rocket motor thrust will result due to variations from standard in surface air pressure (atmospheric pressure at the firing position), propellant weight, and propellant temperature. For a rocket to attain a range and height of burst relative to the launcher corresponding to a listed firing table elevation, these factors would have to equal the following standard values at the time of firing.

	Standard Value	
Ballistic Factor	*HONEST JOHN*	*LITTLE JOHN*
Surface air pressure	1,013 millibars	1,013 millibars
Propellant weight	2,050 lbs (MGR–1A) 1,665 lbs (MGR–1B)	242.6 lbs
Propellant temperature	77° F	77° F

(1) Since changes in air pressure affect the thrust delivered by a rocket motor, a variation in thrust with different altitudes is to be expected. Since the at-

mospheric pressure decreases with increasing altitudes, the thrust will increase if the rocket is propelled at a higher altitude. Therefore, if the surface air pressure (atmospheric pressure) at the firing position is below the standard value of 1,013 millibars, the thrust delivered by the rocket will increase, causing the rocket to exceed the firing table range.

(2) The thrust of a rocket is directly proportional to the propellant weight. Thus, if the propellant weight is greater than the standard value for the rocket, more thrust will be delivered causing the rocket to attain a range greater than the firing table range.

(3) Experience has shown that propellant temperature materially affects performance. On a hot day a given solid propellant will operate at a higher thrust (F) than on a cool day. The firing duration (t) will be shorter, but the total impulse (I) will not be changed significantly. Therefore, using the formula $F = \frac{I}{t}$, it becomes clear that if the propellant temperature exceeds the standard value, thus causing a decrease in the firing duration (t), an increase in thrust (F) will result, causing the rocket to attain a range greater than that shown in the firing tables.

b. Low Level Wind Variations. Propulsion ballistics include the effects of low level winds on the rocket during the powered flight. Low level winds have a considerable effect on both the range and deflection. Because of the location of the fins in relation to the center of pressure, the rocket turns into the wind after leaving the launcher and maintains this attitude throughout its flight.

(1) During powered flight, the thrust of the rocket will cause it to be propelled in the direction in which the nose is pointed. Since the nose is turned into the wind, the rocket will follow a path into the wind and away from the azimuth on which it was fired (fig. 1). The magnitude of this deviation into the wind is dependent on the force of the wind against the fin surface of the rocket. Therefore, corrections based on low level wind velocity and direction must be applied to the firing azimuth in the same direction as the wind to compensate for the low level wind effects during powered flight.

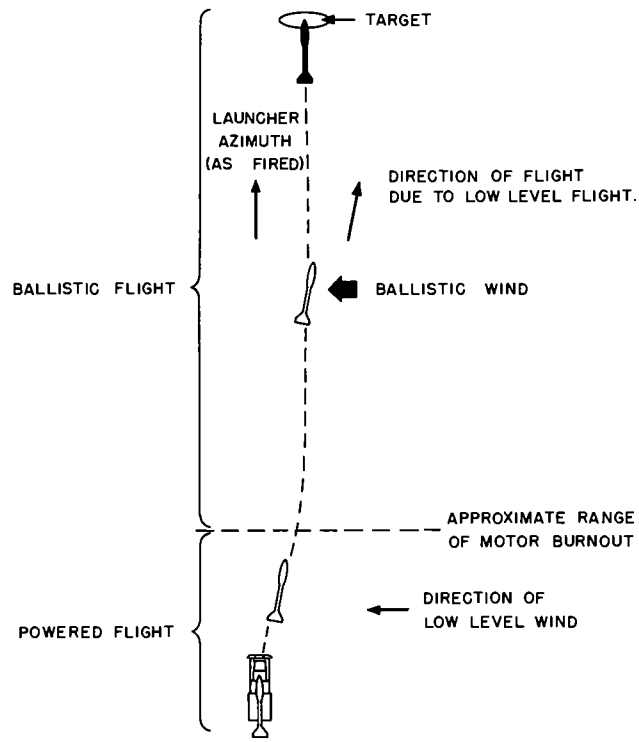

Figure 1. Low level and ballistic wind effects.

(2) After motor burnout, the rocket assumes a ballistic trajectory similar to that of a cannon projectile. The rocket will remain alined into the wind; however, since no thrust is being applied, it will drift with the wind in the same manner as the cannon projectile. Therefore, corrections based on upper ballistic wind velocity and direction

must be applied to the firing azimuth in the opposite direction as the wind to compensate for the upper ballistic wind effects during free flight.

7. Free Flight Ballistics

Free flight ballistics is the study of the motion of the rocket and the factors affecting that motion after burnout. The factors that must be considered are meteorological effects, rotation effects, rocket empty weight effects, and drift effects (MGR–1B rocket).

a. Meteorological Effects. The meteorological (metro) message is a coded tabulation of meteorological information. Firing tables are based on one of two types of metro messages; the Ordnance Standard (U.S.) metro or the North Atlantic Treaty Organization (NATO) Metro Message (DA Form 6–57). A description and explanation of use of the type metro applicable to the firing table can be found in the introduction to the firing table.

(1) The basic differences between the Ordnance Standard (U. S.) metro and the North Atlantic Treaty Organization (NATO) metro are as follows:

(*a*) The altitude of the Metro Datum Plane (MDP) of the U. S. metro is in feet, while the NATO metro MDP is in meters.

(*b*) The U. S. metro does not include surface air pressure in the heading.

(*c*) The metro line numbers are based on different zone heights and do not agree.

(*d*) Wind velocity is measured in miles per hour in the U. S. metro and in knots in the NATO metro.

(*e*) The U. S. metro gives ballistic temperature in degrees Fahrenheit and the NATO metro expresses temperature as a percent of standard.

(*f*) The ballistic density stated in the U. S. metro is expressed as a percent of standard air density for the Ordnance Standard atmosphere. The NATO metro expresses density as a percent of standard based on the International Civil Aviation Organization (ICAO) atmosphere.

Note. To use type 3 NATO metro message with firing tables based on the U. S. metro requires conversion of the NATO message to the U. S. format as described in paragraph 22(*a*)9.

(2) The NATO message, is divided into an introduction and a body. The introduction contains, primarily, identifying information and the body contains meteorological information. The body of the message consists of a number of lines with each line consisting of two 6-number groups. The lines are numbered in sequence from 00 (surface conditions) to 15 (18,000 meter height). Each line furnishes information applicable to firings where the maximum ordinate is equal to a specific standard height which is identified by the first two digits of the line. The content of each line of the message is ballistic wind (azimuth and velocity), ballistic air temperature, and ballistic density for the indicated height. For the 00 line, these quantities refer merely to the actual wind, air temperature, and density in the zone containing the meteorological datum plane (MDP). For other lines, these quantities are certain effective mean values which are used in conjunction with the data given in the applicable firing table for the determination of the corrections of ballistic wind, ballistic air temperature, and ballistic density.

(*a*) *Upper (ballistic) wind.* A rocket traveling a trajectory, the maximum ordinate of which is equal to some particular standard height, passes through successive zones in which the wind has various directions and velocities. The ballistic wind for the standard height is that wind which is constant in velocity and direction and which produces the same effect on the range, height, and deflection of the rocket as the actual wind.

(*b*) *Upper air temperature and density.* There is a hypothetical structure which corresponds to any actual temperature and density structure of the atmosphere and represents

the same effect on range and height of the rocket as the actual structure. These hypothetical structures, expressed as a percentage, are called ballistic temperature and ballistic density.

b. Rotation of Earth. Because of rotation of the earth, corrections must be made to azimuth, elevation, and time of flight (FM 6–40).

c. Rocket Empty Weight. The rocket empty weight is defined as the in flight weight of the rocket at the point on the trajectory at which propellant burnout occurs. The standard motor assembly—warhead section combination empty weight is listed in paragraph 4 of the introduction to the applicable firing tables. If the rocket empty weight is less (more) than standard, the rocket motor thrust will propel the rocket to a greater (lesser) range than will the same thrust for a rocket of standard weight. Corrections for empty weight variations are made to elevation and time of flight in the appropriate direction.

d. Drift. A correction to deflection must be applied to compensate for the effects of drift when firing the MGR–1B rocket. During the propulsion stage, an approximately constant drift to the left occurs regardless of other factors that effect the rocket. Drift corrections are found in the appropriate firing table.

Note. This drift to the left differs from, and should not be confused with, the concept of drift applicable to cannon artillery fires.

8. Noncorrectable Variables

Noncorrectable variations are those which cannot be accurately predicted or measured using present procedures and techniques.

a. Launcher Alinement Limitations. The launcher rail provides the only means of guidance for HONEST JOHN and LITTLE JOHN rockets. The using unit can measure the horizontal and vertical deviations of the launching beam to determine serviceability, but, at the present time, there is no means available to correct an alinement error if one exists.

b. Thrust Malalinement. Spin is imparted to the rockets to reduce the effects of thrust malalinement caused by manufacturing imperfections, uneven burning, and other factors that cause variations in thrust. The initial rotational velocity imparted to the rocket is maintained by a canted fin assembly.

c. Cracking or Flowing of Propellant. Storing a rocket at temperatures above the maximum or below the minimum limits may cause the propellant to crack or flow. Dropping the rocket motor or subjecting it to any shock may cause the propellant to crack. Either cracking or flowing of the propellant will cause unpredictable thrust variations. If rocket motors are exposed to ambient temperatures in excess of storage limits stenciled on the motor or are damaged by rough handling, they should be returned to ordnance for disposition.

d. Aerodynamic malalinements. The rocket must be handled in a manner that will insure retention of proper aerodynamic characteristics. The rocket motor and warhead section must not be dented, scratched, or otherwise damaged. Screwheads must be flush with the skin surface. The rocket should not be painted unless it is absolutely necessary for maintenance purposes. If painting becomes necessary, it normally should be done by ordnance agencies. Painting of rocket components by organizational personnel is limited to spot painting. Damage criteria and spot painting instructions are contained in TM 9–1340–202–12 and TM 9–1340–204–12.

e. Variation in Specific Impulse. Lot-to-lot variations in the propellant grains cause variations in the specific impulse delivered by the rocket motor. This error cannot be corrected but can be minimized if the rocket motor is properly temperature conditioned prior to firing.

CHAPTER 2
FIRE DIRECTION, GENERAL

Section I. FIRE DIRECTION ORGANIZATION

9. General

The fire direction center (FDC) personnel are responsible for the computation of firing data and transmission of fire commands to the firing section. The FDC consists of the gunnery and communication personnel necessary to exercise efficient fire direction. When firing sections are operating separately, augmentation of the FDC may be necessary in order to accomplish the mission.

10. Personnel

a. The battalion FDC is composed of the following personnel:

(1) S3.
(2) Assistant S3 (also S2).
(3) Operations sergeant.
(4) Chief fire direction computer.
(5) Fire direction computers.
(6) Radiotelephone operators.

b. The battery FDC is composed of the following personnel:

(1) Battery executive officer or Assistant executive officer.
(2) Chief fire direction computer.
(3) Assistant chief fire direction computer.
(4) Fire direction computers.
(5) Radiotelephone operators.

c. Personnel are assigned specific duties which are performed in prescribed sequence and manner in order to eliminate confusion and to facilitate speed and accuracy.

11. Duties of Fire Direction Personnel

Duties of personnel pertaining to fire direction are identical for battery and battalion fire direction centers. The following prescribed duties are based on a battalion organization; however personnel in divisional batteries accomplish the same duties, but at the lower echelon.

a. S3. The S3 is the officer responsible for the supervision and operation of the fire direction center and the fire direction team. His duties include—

(1) Supervising the operation of the FDC and training of personnel.
(2) Selecting the battery (launcher(s)) to fire.
(3) Selecting the firing positions for a fire mission. The S3 must consult his fire capabilities overlay to determine whether the target can be attacked from the firing position selected (ch. 4).
(4) Issuing fire orders.
(5) Maintaining a record of the readiness condition and location of all weapons and components.
(6) Determining final minimums quadrant elevation.

b. Assistant S3. In the absence of the S3, the assistant S3 assumes the responsibility for the duties listed in *a* above. He is primarily responsible, however, for the processing of fire missions.

c. Operations Sergeant. The operations sergeant is the principle enlisted assistant to the S3. His duties include—

(1) Maintaining the situation and operation maps.
(2) Preparing records and reports.
(3) Such other duties as may be assigned by the S3 or assistant S3.

d. Chief Fire Direction Computer. The chief

fire direction computer acts for the operations sergeant in his absence. His duties include—

(1) Verifying the computations made by computers.
(2) Distributing metro data.
(3) Maintaining firing charts.
(4) Supervising the work of enlisted members of the FDC.
(5) Assigning duties to enlisted members of the FDC.

e. Fire Direction Computers. The fire direction computers convert the fire mission and fire order into fire commands for individual launchers. Specific duties include—

(1) Recording fire mission.
(2) Recording fire order.
(3) Recording metro messages.
(4) Recording the location of the firing positions.
(5) Recording the firing platoon (section) commander's report.
(6) Computing the vertical interval, azimuth, and range from the firing position to the target.
(7) Computing initial laying data.
(8) Computing corrections for nonstanddard conditions and announcing data to the firing section personnel.
(9) Computing low level wind corrections (unless done at the firing section).
(10) Recording time mission was fired.
(11) Obtaining and recording low level wind corrections applied to the launcher.
(12) Making appropriate entry on the ammunition report for expended rounds.
(13) Recording surveillance information as it is received.

f. Radiotelephone Operators. The radiotelephone operators must be trained in both communications and FDC procedures. Specific duties include—

(1) Operate radio(s) or telephone(s) in the fire direction center.
(2) Transmit warning orders and firing data to the battery (section) designated in the fire order.
(3) Report data received from the firing section and completion of the mission.
(4) Make communication checks as directed.

Section II. FIRE DIRECTION PROCEDURES

12. Definitions and Principles

a. Definitions. Fire direction is the tactical employment of fire power, the exercise of tactical command of one or more units in the selection of targets, the concentration or distribution of fire, and the allocation of ammunition for each mission. Fire direction also includes the methods and techniques used to convert fire missions into appropriate fire commands.

b. Principles. The methods employed in fire direction must insure—

(1) Continuous, accurate, and timely fire support under all conditions of weather, visibility, and terrain.
(2) Flexibility sufficient to engage all types of targets over a wide area.
(3) Prompt massing of fires of all available units in any area within range.
(4) Prompt distribution of fires simultaneously on numerous targets within range.

c. Preparation of Data. Since the computation of firing data for the rocket is more detailed than for cannon artillery, careful planning and precise computations are absolutely necessary.

13. Fire Mission

a. The FDC of the higher artillery headquarters exercising tactical control over the fires of the HONEST JOHN or LITTLE JOHN unit will order the mission to be fired. The fire mission will include applicable elements as follows:

Element	*Example*
(1) Identification	THIS IS DANGER 14
(2) Warning	FIRE MISSION
(3) Type rocket	ROCKET MGR-1B
(4) Type warhead	WARHEAD M38
(5) Launcher number(s)*	( )
(6) Firing position number(s)*	( )
(7) Target coordinates	WX 3675392384
(8) Target altitude	1302 METERS
(9) Height of burst relative to target**	HEIGHT OF BURST ABOVE TARGET 600 METERS
(10) Fuze option**	( )
(11) Height of burst option**	( )
(12) Number of launchers to fire	ONE LAUNCHER
(13) Number of rockets to fire per launcher	ONE ROUND
(14) Predicted time of fire (or Time on target, if appropriate)	TIME ON TARGET 0445
(15) Concentration number	EG 109

b. Depending on the method used to transmit the fire mission, it may not be encoded when received at the unit FDC. If encoded, fire direction personnel must decode it prior to performing the required computations.

14. Fire Order

a. Fire Order. The fire order consists of some or all of the following elements and is announced in the sequence as indicated:

Element	*Example*
(1) Launcher(s) to fire	LAUNCHER NUMBER 2
(2) Firing position(s)	FIRING POSITION NUMBER 1
(3) Concentration number	EG 109

b. Launcher to Fire and Firing Position. Selection of the launcher(s) to fire and firing position(s) is based on the following considerations:

(1) State of readiness.
(2) Time available.
(3) Location of launchers.
(4) Location of the target.
(5) Previous commitments.
(6) Availability of ammunition.

c. Concentration Number. The concentration number is taken from the fire mission received from higher headquarters.

15. Phases of Command

Fire commands originate in the FDC and include all data necessary for positioning, laying (pointing in a known direction), loading and firing the rocket. Low level wind corrections are applied by firing section personnel just prior to firing. These corrections may be determined at

* May be designated by higher headquarters.
** See FM 6-40-1A.

either the FDC or the firing position. Fire commands are normally sent to the firing section in three phases, *a* through *c* below.

a. Warning Order. The first phase, the warning order to the launcher section personnel, includes the following elements:

Element	*Example*
(1) Launcher (s) to fire	LAUNCHER NUMBER 2
(2) Launcher position (s) from which firing is to be conducted	FIRING POSITION NUMBER 1
(3) Type of rocket	ROCKET MGR–1B
(4) Type of warhead	WARHEAD M38
(5) Fuze option*	( )
(6) Height of burst option*	( )
(7) Method of fire	ONE ROUND AT MY COMMAND
(8) Predicted Time of Fire (TOT)	TIME ON TARGET 0445

b. Initial Laying Data. The second phase, initial laying data, includes the following elements:

Element	*Example*
(1) Azimuth of the orienting line	AZIMUTH OF ORIENTING LINE 1020
(2) Azimuth of fire	AZIMUTH OF FIRE 4625
(3) Orienting angle	ORIENTING ANGLE 2795
(4) Quadrant elevation (trial)	QUADRANT 688

c. Corrected Firing Data. The third phase, firing data corrected for nonstandard ammunition and weather (metro) conditions, includes the following elements:

Element	*Example*
(1) Corrected deflection	DEFLECTION 2791
(2) Time of flight	TIME 84.1
(3) Corrected quadrant elevation	QUADRANT 662.2

d. Low Level Wind Corrections. The low level wind corrections are applied just prior to firing. Elements of these corrections are as follows:

Element	*Correction*	*Data Fired*
(1) Deflection	L24	2815
(2) Quadrant elevation	+14.4	676.6

e. Fire commands transmitted to the firing section by the FDC should be encoded by means of a prearranged message code prepared by the unit.

16. Firing Data

a. The computation of firing data for HONEST JOHN and LITTLE JOHN rockets consists of determining an accurate firing azimuth (deflection), time of flight (fuze setting), and quadrant elevation, without the benefit of registration or adjustment. This is a predicted fire technique in which corrections for all measurable variations from established standard conditions are computed and applied to trial data. The degree of accuracy required precludes the use of graphical equipment except as a check against gross computational errors.

b. The sample missions in chapter 3 illustrate the detailed computational procedures. The starting point in the determination of firing data is the computation of the bearing angle and its resultant azimuth of fire, the launcher-target range, and the height of target or burst with respect to the launcher, based on the locations of the launcher and the selected target or burst point. Once these basic data have been de-

* See FM 6–40–1A.

termined, the initial laying data, trial quadrant elevation, and trial time of flight are computed. These data would cause a burst to occur at the desired point if all conditions equalled the standards defined in the construction of the appropriate firing tables. Corrections to deflection, time of flight, and quadrant elevation are computed and applied for nonstandard ammunition and weather conditions, for the effects of the earth's rotation, and for drift (MGR–1B only). In addition, a correction to time of flight to obtain fuze setting is required with selected fuzes. Corrections for the effects of low level winds are determined and applied to the corrected data as close to the time of fire as possible. The unit FDC is responsible for the determination of all data; however, the low level wind corrections are normally determined by the firing section personnel.

c. The computations involved are similar to those used for other field artillery predicted fire techniques. A principal difference is that site is not used in the rocket gunnery problem. The firing tables are arranged in a two-dimensional format and provide directly for horizontal range and height combinations. The elevation angle obtained by entering the tables with range and height with respect to the launcher as arguments is quadrant elevation. Also, the unit corrections for variations from standard conditions are described in mils and seconds in the rocket firing tables rather than in meters.

CHAPTER 3
COMPUTATION OF FIRING DATA

Section I. COMPUTERS RECORDS AND WEIGHTS

17. Computers Record and Data Correction Sheet (DA Form 6–56) (DA Form 2256–1–R).

a. The computers record and data correction sheets assist the fire direction computer in computing and recording firing data. DA Form 6–56 (① and ② fig. 2, and ① and ② fig. 4) are designed to be used with the NATO metro message and firing tables based on the NATO metro. DA Form 2256–1–R, which will be reproduced locally on 8 x 12½ inch paper (① and ② fig. 3), is designed for use with DA Form 6–57 and firing tables based on the U. S. Metro. The NATO message must be converted to the U. S. format for use with DA Form 2256–1–R.

b. Procedure for using these forms is as follows:

(1) Record fire mission from higher headquarters.
(2) Record fire order.
(3) Transmit warning order to proper firing section(s).
(4) Obtain position data from records in FDC.
(5) Compute initial laying data.
(6) Transmit initial data to firing section.
(7) Compute corrected data (determination of metro corrections and corrections for nonstandard ammunition effects).
(8) Transmit corrected data to firing section.
(9) Compute low-level wind corrections (if not computed by the firing section).
(10) Transmit final firing data including low-level wind corrections (unless low-level wind corrections are computed by the firing section).
(11) Record fired data and time mission was fired.

18. Meteorological Data

Among conditions that affect a rocket is the state of the atmosphere through which it passes. The atmospheric (metro) effects that must be considered in the computation of corrections are ballistic wind, low-level wind, temperature, density, and surface pressure. Basically, the same method of computation applies to metro corrections for rockets as for other artillery. In contrast to cannon artillery procedures, corrections are computed for and applied to quadrant elevation and time of flight rather than range. Since range, direction of fire, propellant weight and temperature, rocket empty weight, and other ballistic conditions vary from round to round, separate corrections must be computed for each rocket to be fired.

19. Weights

The determination of weights (empty weight and propellant weight) is critical. In determining weights to be used in FDC computations, the following points must be considered:

a. The stenciled weights appearing on rocket components are to be used in all computations except when firing the MGR–1A rocket from the M386 launcher (*e* below). No additional weights have to be added for closure plug, igniter, fuzes, etc.

b. Certain M3 series rocket motors have been purposely stenciled in error (RAD lots 1–23 and 1–24, and 1–28 through 1–38) so that elevation and time of flight corrections will be computed by the unit to compensate for a low impulse propellant. The propellant weights stenciled on the motors are approximately 21 pounds less than standard. In any event, the

stenciled weights must be used in the computations.

c. There are two types of fins in use with the MGR–1A series rockets. The nominal weight for the appropriate fins must be allowed in all computations—166 pounds is allowed for the M136A2 fins, and 172 pounds is allowed for the M136A2B1 fins. The fin weight for the MGR–1B and MGR–3A rockets is included in the stenciled motor empty weight and is not to be added in the computations to obtain total empty weight.

d. When firing the MGR–1A rocket from either the M289 launcher or the M33 launcher, weights used in FDC computations may be obtained in one of two ways, depending on what weights are stenciled on the rocket. All rockets are not stenciled the same. The correct procedure is as follows:

(1) If the empty weight of the motor is given, add to it the weight of the warhead section and the weight of the fins (166 pounds for the M136A2 and 172 pounds for the M136A2B1) to obtain the total empty weight.

Example:

Motor empty weight	2,025
Plus warhead section weight	+1,634
Plus fin weight (M136A2B1	+ 172
Equals total empty weight	3,831

Data to be used in computations:

Empty weight	3,831
Propellant weight (as stenciled)	2,051

(2) If the motor empty weight is not given add the spin rocket propellant weight to the propellant weight. Then add the warhead section weight, and fin weight to the gross motor weight to obtain the gross rocket weight. Subtract the sum of the spin rocket propellant weight and the propellant weight from the gross rocket weight to obtain empty weight.

Example:

Propellant weight	2,049
Plus spin rocket propellant weight	+ 13.7
Sum propellant weight plus spin rocket propellant weight)	2,062.7
Gross motor weight	4,100
Plus warhead section weight	+1,632
Plus fin weight (M136A2)	+ 166
Equals gross rocket weight	5,898
Minus sum of propellant weight plus spin rocket propellant weight	—2,062.7
Equals total empty weight	3,835.3

Data to be used in computations:

Empty weight	3,835
Propellant weight (as stenciled)	2,049

Note: The MGR–1A rocket will *not* be fired from the M289 and M33 launchers with the rear shoe adapters installed (TM 9–1340–202–12). If a motor with the rear shoe adapters installed is received from the SASP, the adapters must be replaced with the rear shoe plates before the rocket is fired. A check should be made to determine if the stenciled motor empty and gross weights have been changed to reflect the increased weight of the adapters (*e* below). If the adapter weight has been included, eight pounds must be subtracted from the motor empty and gross weights when computing total empty weight.

e. When the MGR–1A is fired from the M386 launcher, the rear launching shoe plates must be replaced by launching shoe adapters (TM 9–1340–202–12). The adapters are heavier than the plates and increase the weight of the rocket by 8 pounds. Normally the rocket is received with the shoe adapters *not* installed, and the additional weight *not* included in any of the stenciled motor weights. If the motor is received with the adapters installed, a check must be made to determine if the stenciled motor weights have been changed to reflect an increase of 8 pounds. Computation of total empty weights will be accomplished as illustrated in *d*(1) and (2) above if the adapter weight is included in the stenciled motor empty and gross weights. If the additional weight has not been included in the stenciled motor empty and gross weights, 8 pounds must be added to compute total empty weight. Correct procedure is as follows:

(1) If the empty weight of the motor is given, add to it the warhead section weight, fin weight and launching shoe adapter weight to determine the empty weight.

Example:

Motor empty weight	2,025
Warhead section weight	+1,634
Fin weight (M136A2)	+ 166
Launching shoe adapters	+ 8
Empty weight	=3,833
Propellant weight (as stenciled)	=2,049

(2) If the motor empty weight is not given, add the spin rocket propellant weight to the propellant weight. Then add the warhead section weight, fin weight and launch shoe adapter weight to the gross motor weight to obtain gross rocket weight. Subtract the sum of the spin rocket propellant weight and the propellant weight from the gross rocket weight to obtain empty weight.

Example:

Propellant weight	2,049
Plus spin rocket propellant weight	+ 13.7
Sum (propellant weight plus spin rocket propellant weight)	2,062.7
Gross motor weight	4,100
Plus warhead section weight	+1,632
Plus fin weight (M136A2)	+ 166
Plus launching shoe adapter	+ 8
Equals gross weight of rocket	5,906
Minus sum of propellant weight plus spin rocket propellant weight	—2,062.7
Equals total empty weight	3,843.3
Data to be used in computations:	
Empty weight	3,843
Propellant weight (as stenciled)	2,049

f. When firing the MGR–1B rocket, the warhead section weight is added to the stenciled motor empty weight to obtain total empty weight. The propellant weight correction will be stenciled on the MGR–1B rocket. This factor combines propellant weight and impulse variations and will be entered on the computers record and data correction sheet as a variation from standard.

Example:

Motor empty weight	1,401
Plus warhead weight	+1,622
Equals total empty weight	3,023
Data to be used in computations:	
Empty weight	3,023
Propellant weight correction (as stenciled)	+ 1.0

Note: The fin weight for the MGR–1B rocket is included in the stenciled motor empty weight and is *not* to be added to obtain total empty weight.

g. When firing the MGR–3A rocket, the warhead section weight is added to the stenciled motor empty weight to obtain the total empty weight. The propellant weight correction is stenciled on the rocket motor. The stenciled weights and propellant weight correction are used in all computations. No additional weights have to be added for any components of the rocket or warhead system.

Example:

Motor empty weight	277 lb
Plus Warhead section weight	+264 lb
Equals total empty weight	541 lb
Data to be used in computations:	
Empty weight	541 lb
Propellant weight correction (as stenciled)	+ 0.2 lb

Section II. SAMPLE MISSION—MGR–1B ROCKET

20. Computation of Firing Data—Light Warhead Section

In determining the procedure to be followed when computing firing data for the HONEST JOHN rocket, several factors must be considered. *For example:* The requirements of the mission dictate what type warhead will be fired and this in turn determines the firing table to be used; the ambient temperature determines the method used to obtain unit corrections for nonstandard propellant temperature; whether the round is to be fired under NIGHTTIME or ALL OTHER THAN NIGHTTIME conditions determines which wind table will be used to determine corrections for low-level winds. The illustrative problem below uses the MGR–1B rocket with the light warhead section.

a. Problem I. In this example the propellant temperature is in the range 20°F to 100°F and low-level wind data are obtained from a wind measuring set (AN/MMQ–1 Mods or AN/PMQ–6). The round is to be fired under ALL OTHER THAN NIGHTTIME conditions. FTR 762–G–1 is applicable in this example. Similar procedures would be used with other firing tables. DA Form 6–56 is conveniently arranged in a logical sequence for computations starting at the top left corner of the form and working across and down.

(1) The following fire mission is received in the FDC:
THIS IS FIREPOWER 3
FIRE MISSION
ROCKET MGR–1B
WARHEAD M27
COORDINATES OF TARGET WX 23370 35505
ALTITUDE OF TARGET 357 METERS
HEIGHT OF BURST ABOVE TARGET 200 METERS
1 LAUNCHER
1 ROUND
TIME ON TARGET 0930
CONCENTRATION EF 109

(2) The S3 issues the following fire order:
LAUNCHER NUMBER 2
FIRING POSITION NUMBER 1
CONCENTRATION EF 109

(3) Based on the information received from the fire mission and the fire order, the following warning order is sent to the firing section:
LAUNCHER NUMBER 2
FIRING POSITION NUMBER 1
ROCKET MGR–1B
WARHEAD M27
ONE ROUND, AT MY COMMAND
TIME ON TARGET 0930

(4) All known values are entered on the Computers Record and Data Correction Sheet (DA Form 6–56, ① and ② fig. 2).
(*a*) Target coordinates WX 23370 35505.
(*b*) Target altitude 357 meters.
(*c*) Launcher coordinates WX 48410 35893.
(*d*) Launcher altitude 446 meters.
(*e*) Azimuth orienting line 285 mils.
(*f*) Empty weight 2620 pounds.
(*g*) Propellant weight correction +1.0 pounds.
(*h*) Propellant temperature 69°F.
(*i*) Latitude of launcher 34°N.
(*j*) Surface air pressure (barometer) 994 millibars.

(5) The following NATO metro message is received:

MET S31	344983
121 416	037990
USL	
004309	029957
013215	029956
022818	033954
032419	039954
042620	039956
052822	044956
062923	046957
073123	048959

(6) Compute and record—
(*a*) *The bearing.* In the block "Computation of Range and Bearing" enter the coordinates of the launcher and target. In this example, since the launcher coordinates for easting and northing are larger than those for the target, it is easily determined that the launcher is northeast of the target and that the direction of fire will be southwest. For convenience in remembering, draw an arrow in the third quadrant of the bearing block in the upper right hand corner. (This corresponds to a –dE and –dN). In the block labeled "Bearing," obtain the logarithmic values of dE and dN from the logarithm tables (TM 6–230) and determine the difference. This is the log tangent of the bearing. The antilog of this gives the bearing (1584.2m).

(*b*) *Azimuth of fire.* Enter the bearing obtained above to the nearest mil (1584) in the appropriate space in the azimuth block at the right hand side of DA Form 6–56. Since the bearing is in the third quadrant,

COMPUTERS RECORD AND DATA CORRECTION SHEET (FREE ROCKET)

UNIT 1/82 | Lchr Lat (N) S 34 | Time and Date Fired 0930 2 APR 64 | Min | FPC 185 ø | Conc Nr EF 109 | QE | FDC 242 ø | Rkt Mtr SN 54126

FIRE MISSION

FIREPOWER 3, FM,
Type Rkt M6R-1B, Whd M27,
Lchr Nr ____, FP Nr ____,
Tgt Coord WX 23370 35505
Tgt Alt 357 m, HOB** Rel Tgt 200 m
Fuze ( ) Air HOB** ( ) High
Opt ( ) Impact Opt ( ) Low
Lchr(s) to Fire 1, Nr Rkts to Fire 1,
~~Pred Time~~ (TOT) ~~of Fire~~ 0930 Conc Nr EF 109

FIRE ORDER

Lchr Nr 2 FP Nr 1
Conc Nr EF 109

WARNING ORDER

Lchr Nr 2, FP Nr 1,
Type Rkt M6R-1B Whd M27,
Fuze ( ) Air HOB ( ) High
Opt ( ) Impact Opt ( ) Low
Method of Fire (1) AMC
~~Pred Time~~ TOT 0930

COMPUTATION OF RANGE AND BEARING

Tgt Coord	23370	35505
Lchr Coord	48410	35893
	dE 25040	dN 388

dE- dN+ 6400 - Bearing
dE- dN- 3200 + Bearing
dE+ dN+ 0 + Bearing
dE+ dN- 3200 -Bearing

BEARING

Log dE	4.398634
Log dN	- 2.588832
Log Tan Bearing	1.809802
Bearing	1584.2 ø

AZIMUTH

0 3200 6400	3200 ø
Bearing	+ 1584 ø
Az of Fire	4784 ø

RANGE

dE Greater than dN

Log dE	4.398634
Log Sin B	- 9.999948
Log Rg	4.398686
Range	25,043 m

dN Greater than dE

Log dN	
Log Cos B	-
Log Rg	
Range	m

Computation** Range (10m) 25,040 m

HOB REL TO LCHR

Tgt Alt	357 m
HOB rel to Tgt**	+ 200 m
Alt of Burst	= 557 m
Alt of Lchr	- 446 m
HOB rel to Lchr	= + 111 m
HOB rel to Lchr (10m)	+110 m

SECOND TRAJECTORY COMPUTATIONS

Alt Tgt		m
Alt Lchr		m
Ht of Tgt rel Lchr	±	m
H_B		m
Ht Tgt rel Lchr	-	m
HOB above Tgt	+	m
Wind Az (100ø)		ø
+6400 (if nec)	+	ø
Sum	=	ø
Az of Fire (100ø)	-	ø
Chart Dir of Wind	=	ø

Computations: (R_B (Trial) and H_B)

MET CORRECTIONS

Line Nr	Wind Az	Wind Vel	Temperature	Density

Alt Tgt ____ m — Density Correction
Alt MDP - ____ m
Alt Diff ____ m — Corrected Value

Ballistic Factors	Known	Std	Var fr Std	Unit Corr	+/-
Density		100%	D I		
Rg Wind		0 Kn	H T		
Met Corr to R_B (Trial)					

R_B

R_B (Trial)	m
Met Corr to R_B	+ - m
R_B (Corr)	m

RANGE H ____ H
WIND T ____ (Comp) X ____ (Vel) = T ____ Knots

CROSS L ____ L ____ L
WIND R ____ (Comp) X ____ (Vel) = R ____ X ____ (Unit Corr) = R ____ ø

**See FM 6-40-1A (Honest John/Little John)

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Figure 2 ①. Computers record and data correction sheet (Free Rocket) (DA Form 6-56).

Firing Table Entry Range (Computation Range or $^{R}_{B}$ (Corr)) 25,040 m	Firing Table Entry Height of Burst (HOB rel to Lchr (10 m) or H_B) +110 m
Alt of Lchr 446 m / Az of Fire 4784 ‰	Latitude of Lchr (10°) 30 / Df Corr (N) S / L (2d Traj) R ___ ‰

Initial Laying Data*	
*Az of OL	285 ‰
+6400 (if nec)	+6400 ‰
Sum	=6685 ‰
*Az of Fire	-4784 ‰
Difference	=1901 ‰
~~-3200 (if nec)~~	- ‰
*Orienting Angle	=1901 ‰
*QE (Trial)	423 ‰
Alt Lchr (10m)	450 m
Alt MDP (10m)	- 370 m
Lchr (above) below MDP	+ 80 m
Az of Wind (100‰)	2900 ‰
+ 6400 (if nec)	+6400 ‰
Sum	=9300 ‰
Az of Fire (100‰)	-4800 ‰
Chart Dir of Wind	=4500 ‰

Computations (QE (Trial), TF (Trial), and Surface Pressure):

QE

421.5 + (10/100) 3.3 = 421.5 + 0.3 = 421.8

421.8 + (40/100) 2.9 = 421.8 + 1.2 = 423.0

TF

54.43 + (10/100)(-).07 = 54.43 - 0.01 = 54.42

54.42 + (40/100) .37 = 54.42 + 0.15 = 54.57

SP

994 mb CORRESPONDS TO 98.1% OF STD.

Met Station			Use	Type	Oct	Latitude			Longitude		
M	E	T	S	3	1	3	4	4	9	8	3
Day		B. Time		E. Time		Altitude MDP			Sur. Press. (SL)		
1	2	1	4	1	6	0	3	7	9	9	0
Line Nr		Wind Az		Wind Vel		Temperature			Density		
0	6	2	9	2	3	0	4	6	9	5	7
Temperature-Density Corr						-	0.	2	-	0.	8
Corrected Values					1	0	4.	4	9	4.	9

RANGE WIND H (I) .29 Comp × 23 Vel H (T) 7 Knots

CROSS WIND (L) R .96 Comp × 23 Vel (I) = R 22 × .54 Unit Corr (L) = R 12 ‰

BALLISTIC FACTORS	Std	Known	Variation from Std	Unit Corr to QE	+	-	Unit Corr to TF	+	-
Propellant Temperature	77°F	69°	° Decrease (I) 8.0	+ .25	2.00		+ .016	.128	
Propellant Wt	lb		D (I) 1.0	- .51		.51	- .040		.040
Surface Pressure	100%	98.1	(I) 1.9	- .47		.89	- .036		.068
Density	100%	94.9	(I) 5.1	- 4.41		22.49	- .444		2.264
Air Temperature	100%	104.4	D (I) 4.4	+ 1.41	6.20		+ .100	.440	
Empty Weight	2630 lb	2620	(I) 10	- .14		1.40	- .008		.080
Range Wind	0 Knots	T 7	H (T) 7	- .42		2.94	- .053		.371
					8.20	28.23		.568	2.823
						8.20			.568
			Met Corr to QE and TF			20.03			2.255

DEFLECTION	L	R	QUAD ELEVATION	+	-
Df Corr(2d Traj)	___	___	Met Corr		20.0
Cross Wind Corr	12		Rotation Corr	2.6	
Rotation Corr	2		Rail Aline Corr		
Drift Corr		6			
Rail Aline Corr					
	14				
	- 6				
Total Df Corr	8		Total QE Corr		17.4
Aiming Post Df	2	800	QE (Trial)		423.0
Df Correction (I) R		8	QE Correction		17.4
Df (Corrected)	2	808	QE (Corrected)		405.6
Low Level Wind	L (R)	14	Low Level Wind		8.8
Df Fired	2	794	QE Fired		414.4

FUZE SETTING	+	-
Met Corr		2.26
Rotation Corr		0
Rail Aline Corr		
Total TF Corr		2.26
TF (Trial)		54.57
TF Correction		2.26
TF (Corrected)		52.3
Fuze Corr		.2
FS Fired		52.1

Figure 2 ②. Computers record and data correction sheet (Free Rocket) (DA Form 6-56).

add 3200 mils to the bearing to obtain the azimuth of fire (4784 mils).

(*c*) *Launcher-target range.* First, determine which is the greater, dE or dN, and enter the values obtained from the log table on the appropriate lines of the RANGE block. After the range is computed (25,043 meters), enter this value in the "Computation Range" block immediately below to the nearest 10 meters (25,040 meters).

(*d*) *Height of burst relative to launcher.* In the HOB REL TO LCHR block, enter the target altitude (357 meters) and the HOB relative to the target (200 meters). This information is obtained from the FIRE MISSION block. Add these two values to obtain the altitude of the burst (557 meters). From the altitude of the burst, subtract the altitude of the launcher (446 meters) to obtain the height of burst relative to the launcher (+111 meters). Record this value in the space provided to the nearest ten meters (+110 meters).

(*e*) *Computations on reverse of form.* Since this example does not include second trajectory computations, the remainder of the problem will be computed on the reverse side of the form. At the top of the form on the reverse side enter the firing table entry range (computation range) (25,040 meters), Firing Table Entry Height of Burst (+110 meters) altitude of launcher (446 meters), azimuth of fire (4784 mils), and latitude of launcher to nearest 10° (30°N). These values are obtained from the computations performed on the front side of the form.

(*f*) *Value of orienting angle.* In the "Initial Laying Data" block enter the azimuth of the orienting line (285 mils), subtract the azimuth of fire (4784 mils), adding 6400 if necessary, and obtain the value of the orienting angle (1901 mils).

(7) Trial QE is determined by entering table G of FTR 762–G–1 with range to the nearest 200 meters and obtaining the elevation from column E2 corresponding to the firing table entry Height of Burst (HOB relative to launcher) in column E1.

Note. Since some free rocket firing tables list entry ranges in 200 meter intervals, in some cases it may be necessary to examine the exact computed launcher-target range (before roundoff) to determine the proper entry range. For conformity in entering the firing tables, the following guide is furnished as an example:

If launcher-target range is 24,900 through 25,099 meters inclusive, entry range is 25,000 meters.

If launcher-target range is 25,100 through 25,299 meters inclusive, entry range is 25,200 meters.

(*a*) In this example, to obtain the elevation (column *E2) corresponding to the launcher-target range of 25,040 meters, entry to the firing table is made at range 25,000 meters and HOB relative to launcher of +110 meters (column E1). To do this, interpolation is necessary between +100 meters and +200 meters HOB as follows:

$$\begin{array}{ccccc} & HOB & & EL & \\ 100 & \begin{bmatrix} 200 \\ 110 \\ 100 \end{bmatrix} & 10 & X \begin{bmatrix} 424.8 \\ ? \\ 421.5 \end{bmatrix} & 3.3 \end{array}$$

$$\frac{10}{100} = \frac{X}{3.3} \text{ or } X = 3.3 \left(\frac{10}{100}\right) = 0.3$$

Therefore, the elevation corresponding to HOB of +110 meters and range 25,000 meters = 421.5 + 0.3 = 421.8 mils.

(*b*) Since this value was obtained at an entry range of 25,000 meters, computation must still be made for the additional 40 meters of range. This is accomplished by use of the c factor found in column E3 of the same table. Entry is made to the nearest hundred meter HOB (+100), and the corresponding c factor (+.9) is obtained. This factor represents the number of mils in elevation neces-

sary to change the range 100 meters. The elevation change corresponding to the additional 40 meters in range is computed as follows: 40/100 X 2.9 = 1.16 mils or 1.2. Add this value to the elevation already computed for range 25,000 meters and HOB +110 meters (421.8) and obtain the trial QE of 423.0 mils (421.8 + 1.2 = 423.0). This value is entered in the bottom space of the initial laying data block to the nearest mil and in the QE (Trial) space at the bottom center of the form to the nearest tenth mil.

(*c*) Transmit initial laying data to the firing section:

1. Azimuth of the orienting line	285 mils
2. Azimuth of fire	4,784 mils
3. Orienting angle	1,901 mils
4. Trial QE	423 mils

(Each element of the initial laying data is transmitted to the firing section as soon as it is obtained to preclude any delay at the firing section.)

(*d*) Trial time of flight (TF) is determined in the same manner as trial QE. Entry to Table H of the firing table is made using the same range (25,000) and HOB (+110). Time of flight corresponding to 25,000 meters and HOB of +110 meters is determined by interpolation as follows:

	HOB		TF
100	200	10 X	54.36
	110		? 0.07
	100		54.43

$$\frac{10}{100} = \frac{X}{-0.07} \text{ or } X = -0.07\,\frac{10}{100}$$

$$= -.007 \text{ or } -0.01$$

Therefore, the time of flight corresponding to HOB of +110 meters and range 25,000 meters is 54.42 seconds (54.43 —0.01 = 54.42).

(*e*) As with the trial QE, computation must be made for the additional 40 meters of range beyond 25,000 meters. This is accomplished by using the t factor found in column T3 of Table H. Entry is made to the nearest hundred meter HOB (100) and the corresponding t factor (.37) is obtained. The time of flight change corresponding to the additional 40 meters is computed as follows. 40/100 X .37 = .15 seconds. This value is added to the time of flight computed in (*d*) above (54.42) and the trial time of flight of 54.57 seconds is obtained (54.42 + .15 = 54.57 seconds). This value is not sent to the firing section, but is entered in the TF (Trial) space at the lower right-hand corner of the form.

Note. The blank space on the reverse side of form 6–56 is for use in computing Trial QE and Trial TF.

(8) The trial QE having been determined, it is now possible to find and reduce the data of the met message to a form that can be used in computing corrections to Trial QE, Trial TF, and deflection for nonstandard meteorological conditions.

(*a*) Enter the values from the heading of the met message in the appropriate spaces on the form.

(*b*) From Table A, entered with the trial QE of 423 mils, the line number applicable to this particular fire mission is found to be 06.

(*c*) The data for line 06 (uncorrected for the difference in the altitudes of the launcher and MDP) are—

06 29 23 104.6 95.7

These data are entered in the appropriate spaces on the form.

(*d*) Since temperature and density vary appreciably with altitude, corrections must be made to compensate for the difference in altitude between the launcher and the MDP. To accomplish this, first obtain the difference in altitude of the launcher and the MDP, using the space at the left side of the form directly beneath the trial QE block.

Altitude of Launcher (446) to nearest 10 meters 450 meters
Minus Altitude of MDP —370 meters
Difference (Launcher above MDP) = +80 meters

Table B is entered at the height of launcher with reference to MDP (+80 meters) to obtain a correction to air temperature of —.2 percent and a correction to air density of —.8 percent. These corrections are then applied to the air temperature and density recorded from line 06 of the met message.

	TEMPERATURE	*DENSITY*
	104.6	95.7
	—.2	—.8
CORRECTED	104.4	94.9

Line 06 of the met message (corrected) now reads:
06 29 23 104.4 94.9
Enter these values in the appropriate space provided on the form.

(9) Surface air pressure measured with a barometer at the firing position (994 millibars) must now be converted to a percent of standard air pressure. Enter Table C with 994 millibars to obtain 98.1 percent.

Note. If the surface air pressure from a barometer is unavailable, the surface air pressure from the heading of the metro message may be used. This value is less accurate than that taken with a barometer at the firing position and should be used only when necessary. The surface air pressure of the metro message may be either the value at the MDP or at mean sea level MSL). The procedures for using these values is outlined in problem V and VI.

(10) The met message is now applicable to the firing problem being solved; but, before actual corrections can be made for existing meteorological conditions, the ballistic wind data must be reduced to cross wind and range wind components.

(*a*) Determine the chart direction of the ballistic wind by subtracting the azimuth of fire from the azimuth of the ballistic wind, adding 6,400 mils if necessary. This procedure yields—

Azimuth of ballistic wind 2900m
(+6400 mils) 6400m
9300m
Azimuth of fire (4784 to nearest 100m) —4800m
Chart direction of ballistic wind 4500m

(*b*) Using this chart direction, the "correction components of a unit wind" table (page 14) is entered to obtain—

Range wind correction component = T.29
Cross wind correction component = L.96

The ballistic cross and range winds are the products of the wind velocity from line 06 of the met message (23 knots) and the correction components just determined. Hence,

Ballistic range wind = T.29 × 23 = T7 knots
Ballistic cross wind = L.96 × 23 = L22 knots

(11) A correction to deflection must be made to compensate for the ballistic cross wind. From Table F (Range = 25,000 meters), the unit correction factor for a ballistic cross wind of 1 knot (column 11) is found to be 0.54m. The correction for a cross wind of L22 is: L22 × 0.54 = L12m.

(12) Corrections to QE and TF must be made to compensate for nonstandard conditions of materiel and weather.

(*a*) First, compute variations from standard of all metro and ammunition data and enter the variation from standard in the appropriate column of the BALLISTIC FACTORS block of the form as shown below.

Ballistic factors	Standard	Known	Variation from std
Propellant temperature	77°F	69°F	Dec 8
Propellant weight	* lbs	+1.0	Inc 1.0
Surface pressure	100%	98.1%	Dec 1.9
Density	100%	94.9%	Dec 5.1
Air temperature	100%	104.4%	Inc 4.4
Empty weight	2630 lbs	2620 lbs	Dec 10
Range wind	0 knots	Tail 7 knots	Tail 7

* MGR 1A rocket motors use the propellant weight. MGR-1B rocket motors use a propellant weight correction.

(*b*) Next, determine the unit corrections to QE and TF by entering tables G and H at range 25,000 meters and height 100 meters. The column chosen to obtain unit corrections for variation from standard conditions is dependent on whether the variation is an *increase* or *decrease*.

(*c*) Finally, the unit correction factors obtained in (*b*) above are multiplied by the variations from standard obtained in (*a*) above and summed algebraically to find the total corrections to QE and TF. Sample computations are as follows:

Ballistic factors	Variation from std	Unit corr. to QE	+	−	Unit corr. to TF	+	−
Propellant Temperature	Ⓓ I 8	+ .25	+2.00		+.016	+.128	
Propellant Weight	D Ⓘ 1.0	— .51		— .51	—.040		— .040
Surface Pressure	Ⓓ I 1.9	— .47		— .89	—.036		— .068
Density	Ⓓ I 5.1	—4.41		—22.49	—.444		—2.264
Air Temperature	D Ⓘ 4.4	+1.41	+6.20		+.100	+.440	
Empty Weight	Ⓓ I 10	— .14		— 1.40	—.008		— .080
Range Wind	H Ⓣ 7	— .42		— 2.94	—.053		— .371
Total Corrections			+8.20	—28.23		+.568	—2.823
				+ 8.20			+0.568
	Corr to QE and TF			—20.03			—2.255

Enter the corrections obtained above in the appropriate space immediately below and in the proper column (+ or —). The correction to QE (20.03) is entered to the nearest tenth mil (—20.0) and the correction to TF (—2.255) is entered to the nearest hundredth second (—2.26).

(13) Corrections to deflection must be made to compensate for rotation of the earth and drift of the rocket during burning phase.

(*a*) Table I is entered with the latitude to the nearest 10° (30°N); azimuth of fire to the nearest 400 mils (in this case 4800 mils); and range to the nearest 2,000 meters (26,000). The correction for rotation of the earth is L2m.

(*b*) Table J is entered at range to the nearest 1,000 meters (25,000 meters) and propellant temperature to the nearest 10° (70°F). The drift correction is R6m.

(*c*) Assuming an aiming point deflection of 2800 mils and combining the correction for a cross wind (L12m) obtained in (11) above with the corrections for rotation of the earth (L2m) and drift (R6m), the corrected deflection is 2808 mils (2800 +12 + 2 —6 = 2808m).

Note. The standard rule for deflection applies: left—add; right—subtract.

(14) To adjust QE and TF for rotation of the earth, corrections are first found for the launcher-target range and azimuth of fire at 0° latitude and then multiplied by a factor in order to convert them to corrections for the latitude of the launcher. These corrections are found by entering Table K at range 26,000 meters and azimuth 4800m. The corrections are—

QE correction at 0° latitude = 3m.

TF correction at 0° latitude = 0 sec.

Correction factor at 30°N latitude = .87 (from table under table K).

Therefore, the corrections for rotation to QE and TF are—

QE correction = $+3\text{mil} \times .87 = +2.6\text{mil}$

TF correction = 0 sec. $\times$ .87 = 0 sec.

(15) The total corrections to QE and TF are the sums of the corrections for nonstandard conditions of weather and materiel and the corrections for rotation. Thus, the total QE correction = —20.0 (met correction) +2.6 (rotation correction) = —17.4mil. The total TF correction = —2.26 (met correction) + 0 (rotation correction) = —2.26 seconds. Adding these corrections to the trial QE and the trial TF gives: Corrected QE = 423.0mil —17.4mil = 405.6mil

Corrected TF = 54.57 sec —2.26 sec = 52.31 or 52.3 seconds.

(16) A correction to TF must be made to compensate for a bias in the M7 timer. This is found in table L and yields a fuze correction of —.2 seconds. Adding this to the corrected TF results in fuze setting fired of 52.1 seconds (52.3 seconds —0.2 = 52.1 seconds). The fire commands can now be sent to the firing section. These are—

Deflection	2808	mils
Time	52.1	seconds
Quadrant elevation	405.6	mils

(17) Corrections to deflection and QE must be made to compensate for low-level winds and may be determined by the firing section leader at the firing position or at FDC. These computations are normally made approximately 2 minutes prior to firing. Conditions are ALL OTHER THAN NIGHTTIME. The cross wind and range wind are obtained from the wind speed indicator of the wind measuring set. The readings are—

Cross wind = R5 MPH

Range wind = H9 MPH

(*a*) The deflection and range correction factors are found by entering Table M–1 with the corrected QE to the nearest mil (406mil).

Note. For NIGHTTIME conditions Table M–2 would be entered.

The products of these factors and the cross wind and range wind give the deflection and range corrections.

(*b*) By interpolation, for QE 406mil, Table M–1 gives a deflection correction factor of 2.86. Deflection correction = 2.86 $\times$ R5 = R14.3 = R14 to the nearest mil.

(*c*) By interpolation, for QE 406mil, Table M–1 gives a QE correction factor of +0.98. QE correction +0.98 $\times$ H9 = H8.8mil.

Note. No low-level wind correction is applied to time of flight.

(*d*) The deflection fired and the QE fired are obtained by adding the low-level wind corrections to the corrected deflection and corrected QE. Deflection fired = 2808 —14 = 2794m. QE fired = 405.6mil + 8.8mil = 414.4mil.

b. Problem II. If the propellant temperature is in the range 20°F to —30°F, a different procedure must be followed to determine the correction for a decrease in propellant temperature. This difference in procedure is necessary to increase the accuracy of the unit correction factor since such a large decrease from the standard propellant temperature of 77°F is involved. Computation is as follows:

(1) First, columns E5 of Table G and T5 of Table H are entered to obtain the corrections to QE and TF to compensate for the 57°F decrease in propellant temperature from 77°F to 20°F.

(2) Next, columns E6 and T6 of the same tables, are entered to obtain the unit corrections applicable in the range 20°F to —30°F. These are used in the usual manner to obtain corrections for the decrease in propellant temperature from 20°F to the observed value.

(3) Finally, the sums of the corrections above equal the total corrections to be applied to QE and TF for the decrease from 77°F to the observed propellant temperature.

(4) As an example of the procedure just explained, assume that a firing is to be conducted at the same range (25,040 meters) and height of burst (+110 meters) of Problem I and with a propellant temperature of +5°F. The computation would then be as follows:

	QE		*TF*
Corrections for 57°F decrease (77°F to 20°F, columns E5 & T5).	14.0 mils		0.91 sec.
Corrections for 15°F decrease (15 × 0.34) (20°F to 5°F).	5.1 mils	(15 × 0.019)	0.285 sec.
Corrections for 72°F total decrease (77°F to 5°F).	19.1 mils		1.195 sec.

c. Problem III. If, in Problem I, the range had been 24,960 meters instead of 25,040, then tables G and H would have been entered with the value of 25,000 meters and firing table values of QE, TF, c and t would have been the same. However, the trial QE and TF would have been determined by applying the c and t factors in the opposite direction. Thus, for a range of 24,960 meters, trial QE and trial TF would have been determined as follows:

Trial QE = 421.8 — (40/100) 2.9 = 420.6 mils.

Trial TF = 54.42 — (40/100) .37 = 54.27 sec.

d. Problem IV. If a properly functioning wind set is not available, a pilot balloon technique (para. 37) may be used to determine low-level winds. If neither the wind set nor the pilot balloon is available, line 00 of the metro message may be used to determine low-level winds. The chart direction of the wind is determined as in *a* above except that the wind direction (azimuth) from line 00 is used. For the metro message given in that problem, the chart direction of the wind is 5,900 mils. Using this chart direction of the wind, enter the "Correction" component table (of a unit wind) and obtain—

Range wind correction component = H.88

Low level cross wind correction component = R.47

The line 0 wind velocity is 9 knots which must be converted to MPH for use with wind table M3. The conversion factor is 1.1508.

Multiply 9 knots × 1.1508 = 10 MPH

Hence, the range and cross components of the low-level wind are

10 × 4.88 = H9 MPH

10 × R.47 = R5 MPH

Finally, the QE and deflection corrections are found by forming the product of these low-level wind components and the appropriate correction factor from Table M-3 (MET LINE 0) entered with QE = 406m. The final corrections are—

QE correction = H9 × .79 = H7.1m

Deflection correction = R5 × 2.32 = R12m

e. Problem V. If a properly functioning barometer is unavailable, the heading of the met message may be used to determine the surface air pressure. If the surface air pressure reported in the heading of the met message is referenced to the MDP, Table B is entered (height of launcher above MDP = +80 meters) to obtain —0.9%.

MDP surface air pressure + surface air pressure correction for launcher height relative to the MDP = surface air pressure at launcher altitude; or 99.0 + (—0.9) = 98.1%.

f. Problem VI. If in problem V, the surface air pressure from the heading of the met message is referenced to mean sea level (MSL), enter Table D with the altitude of launcher above MSL to the nearest 10 meters. For problem I, this value was +450 meters. Table D is entered with altitude of launcher = 450 meters to obtain—

MSL surface air pressure + surface air pressure correction for launcher altitude = surface air pressure at launcher altitude; or 99.0 + (—5.4) = 93.6%.

21. Computation of Firing Data—Heavy Warhead Section

Computation of firing data for the MGR-1B rocket with the heavy warhead section is simi-

lar in procedure to that covered above. Reference should be made to FTR 762–H–1 (for M386 launcher) and FTR 762–ADD–C–1 (which is applicable to all 762–mm launchers) for discussion of the gunnery procedures and sample problem.

Section III. SAMPLE MISSION—MGR–1A ROCKET

22. Computation of Firing Data

The procedure to be used in the computation of firing data for MGR–1A rockets is illustrated in the following example. The basic computations are identical to those used with MGR–1B rockets as discussed in Section II.

a. Problem I. FTR 762–F–1 and DA Form 2256–1–R (fig. 3 ① and ②) are used in this example. The propellant temperature is in the range, 77°F to 120°F. The low-level wind data are obtained from a wind measuring set. The existing wind profile at the time of fire is, NIGHTTIME CONDITIONS.

(1) The following fire mission is received in the FDC.
THIS IS FIREPOWER 3
FIRE MISSION
ROCKET MGR–1A
WARHEAD M38
COORDINATES OF TARGET WX-4160700466
ALTITUDE OF TARGET 393 METERS
HEIGHT OF BURST ABOVE TARGET 300 METERS
1 LAUNCHER
1 ROUND
TIME ON TARGET 0500
CONCENTRATION EF122

(2) The S3 issues the following fire order:
LAUNCHER NUMBER 2
FIRING POSITION NUMBER 1
CONCENTRATION EF122

(3) Based on the information received from the fire mission and the fire order, the following warning order is sent to the firing section:
LAUNCHER NUMBER 2
FIRING POSITION NUMBER 1
ROCKET MGR–1A
WARHEAD M38
1 ROUND, AT MY COMMAND
TIME ON TARGET 0500

(4) All known values are entered on the Computers Record and Data Correction Sheet (DA Form 2256–1–R, fig. 3 ① and ②).
(*a*) Target coordinates WX4160700466
(*b*) Target altitude 393 meters
(*c*) Launcher coordinates WX5888596-224
(*d*) Launcher altitude 357 meters
(*e*) Azimuth of orienting line 1258 mils
(*f*) Empty weight 3840 pounds
(*g*) Propellant weight 2049 pounds
(*h*) Propellant temperature 80°F
(*i*) Latitude of launcher 32°N
(*j*) Surface air pressure (barometer) 1007 millibars.

(5) The following NATO metro message is received:

METS31	344983
121012	037036
USL	
004309	029951
014209	029956
023308	029954
032419	039954
042620	039956
052723	039957
062720	050957

(6) Compute and record:

(*a*) Bearing	1354.8	mils
(*b*) Azimuth of fire	5045	mils
(*c*) Launcher-target range	17,791	meters
(*d*) Height of burst relative to launcher	+336	meters

The above data are computed as outlined in paragraph 20*a*, expressed to the appropriate accuracies, and entered on the reverse side of DA Form 2256–1–R.

(7) Compute the initial laying data as follows:

Azimuth of orienting line	1258	mils
plus 6400 mils	+6400	mils
Sum	7658	mils
minus azimuth of fire	—5045	mils
Orienting angle	2613	mils
Trial QE ((8) below)	501	mils

COMPUTERS RECORD AND DATA CORRECTION SHEET (Honest John Rocket M31)

UNIT	Lchr Lat	Time and Date Fired			Conc Nr
1/82	32 °S (N)	0500 2 APR 64	Min	FPC 183 m	EF 122
			QE	FDC 247 m	Rkt Mtr SN 52764

FIRE MISSION

FIREPOWER 3 FM,
Type Rkt MGR-1A, Whd M 38,
Lchr Nr ____, FP Nr ____,
Tgt Coord WX 41607 00466
Tgt Alt 393 m, HOB** Rel Tgt 300 m
Fuze ( )Air HOB**( ) High
Opt ( )Impact Opt ( ) Low
Lchr (s) to Fire 1, Nr Rkts to Fire 1,
~~Pred Time~~ (TOT) Conc ~~of Fire~~ 0500 Nr EF 122

FIRE ORDER

Lchr Nr 2 FP Nr 1
Conc Nr EF 122

WARNING ORDER

Lchr Nr 2, FP Nr 1,
Type Rkt MGR-1A, Whd M 38,
Fuze ( )Air HOB ( )High
Opt ( )Impact Opt ( )Low
Method of Fire (1) AMC
Pred Time TOT 0500

COMPUTATION OF RANGE AND BEARING

Tgt Coord	41607	00466
Lchr Coord	58885	96224
	dE (E) 17278	dN (N) 4242

dE- dN+ 6400 -Bearing | dE+ dN+ 0 +Bearing
dE- dN- 3200 +Bearing | dE+ dN- 3200 -Bearing

BEARING

Log dE	4.237493
Log dN	- 3.627571
Log Tan Bearing	0.609922
Bearing	1354.8 m

RANGE

dE Greater than dN

Log dE	4.237493
Log Sin B	- 9.987293
Log Rg	4.250200
Range	17,791 m

dN Greater than dE

Log dN	
Log Cos B	-
Log Rg	
Range	m

Computations ** Range (10m) 17,790 m

AZIMUTH

0 3200 6400	6400 m
Bearing	(E) 1355 m
Az of Fire	5045 m

HOB REL TO LCHR

Tgt Alt	393 m
HOB rel to Tgt **	+ 300 m
Alt of Burst	= 693 m
Alt of Lchr	- 357 m
HOB rel to Lchr	= + 336 m
HOB rel to Lchr (10m)	+ 340 m

SECOND TRAJECTORY COMPUTATIONS

Alt Tgt		m
Alt Lchr	-	m
Ht of Tgt rel Lchr	+ -	m
H_B		m
Ht Tgt rel Lchr	-	m
HOB above Tgt	+	m
Wind Az (100m)		m
+6400 (if nec)	+	m
Sum	=	m
Az of Fire (100m)	-	m
Chart Dir of Wind	=	m

Computations: (R_B (Trial) and H_B)

MET CORRECTIONS

Line Nr	Wind Az	Wind Vel	Temperature	Density

Alt Tgt ____ m — Density Correction
Alt MDP - ____ m — Corrected Value
Alt Diff ____ m

Ballistic Factors	Known	Std	Var fr Std	Unit Corr	+/-
Density		100%	D I		
Rg Wind		0 Kn	H T		
Met Corr to R_B (Trial)					

R_B	
R_B (Trial)	m
Met Corr to R_B	+ - m
R_B (Corr)	m

RANGE WIND H T____ X____ (Comp / Vel) = H T____ Knots

CROSS WIND L R____ X____ (Comp / Vel) = L R____ X____ (Unit Corr) = L R____ m

DA FORM 2256-1-R, 1 Jan 62

Figure 3 .①. Computers record data correction sheet (for use with MGR-1A Rocket) (DA Form 2256-1-R).

COMPUTERS RECORD AND DATA CORRECTION SHEET (HONEST JOHN ROCKET M31)

Firing Table Entry Range (Computation Range or R_B (Corr)) 17,790 m | Firing Table Entry Height of Burst (HOB rel to Lchr (10m) or H_B) +340 m

Alt of Lchr 357 m | Az of Fire 5045 m | Latitude of Lchr (10°) 30 (N) °S | Of Corr L (2d Traj) R ——— m

Initial Laying Data*	
*Az of OL	1258 m
+6400 (if nec)	+6400 m
Sum	=7658 m
*Az of Fire	−5045 m
Difference	=2613 m
~~3200 (if nec)~~	~~m~~
*Orienting Angle	=2613 m
*QE (Trial)	501 m
Alt Lchr (10m)	360 m
Alt MDP (10m)	− 370 m
Lchr above (below) MPO	− 10 m
Az of Wind (100m)	2700 m
+6400 (if nec)	+6400 m
Sum	=9100 m
Az of Fire (100m)	−5000 m
Chart Dir of Wind	=4100 m

Computations (QE (Trial), TF (Trial), and Surface Pressure).

QE 499 + (40/100) 5 = 499 + 2.0 = 501.0

501 − (10/100) 4.0 = 501 − 0.4 = 500.6

TF 45.0 + (40/100) 0.1 = 45.0 + .04 = 45.04

45.04 − (10/100) 0.42 = 45.02 − 0.04 = 45.00

SP = 1007 mb.

NATO MET MESSAGE

Met Station			Use	Type	Oct	Latitude			Longitude		
M	E	T	S	3	1	3	4	4	9	8	3

Day		B Time		E Time		Altitude MDP			Sur. Press (SL)		
1	2	1	0	1	2	0	3	7	0	3	6

Line Nr		Wind Az		Wind Vel		Temperature			Density		
0	5	2	7	2	3	0	3	9	9	5	7

Density-Temperature Corr			0.0		+ 0	.1
Corrected Values	10	3.9	9	5.	8	

ORDNANCE STANDARD (US) MET MESSAGE

Line Nr		Wind Az		Wind Vel		Density			Temperature	
0	5	2	7	2	6	9	5	8	7	9

RANGE WIND (H) .63 (Comp) × 26 (Vel) (H) 16 mph

CROSS WIND (R) .77 (Comp) × 26 (Vel) = (L) 20 × .44 (Unit Corr) = (R) 9 m

BALLISTIC FACTORS	Std	Known	Variation from Std	Unit Corr to QE	+	−	Unit Corr to TF	+	−
Propellant Temperature	37° Decrease								
	77°F	80	D (1) 3	−.40		1.20	−.017		.051
Propellant Wt	2050 lb	2049	D I 1	+.44	.44		+.027	.027	
Surface Pressure	1013mb	1007	D I 6	−.069		0.41	−.0043		.026
Density	100%	95.8	D I 4.2	−3.52		14.78	−.288		1.210
Air Temperature	59°F	79	D (1) 20	+.10	2.00		+.004	.080	
Empty Weight	3850 lb	3840	D I 10	−.11		1.10	−.006		.060
Range Wind	0 mph	T16	H (T) 16	−.38		6.08	−.039		.624
					2.44	23.57		.107	1.971
						2.44			.107
			Met Corr to QE and TF			21.13			1.864

DEFLECTION	L	R
Df Corr(2d Traj)	———	
Cross Wind Corr	9	
Rotation Corr	1	
Rail Align Corr		
Total Df Corr	10	

QUAD ELEVATION	+	−
Met Corr		21.1
Rotation Corr	1.7	
Rail Align Corr		
		(+) 1.7
Total QE Corr		19.4

FUZE SETTING	+	−
Met Corr		1.86
Rotation Corr		0
Rail Align Corr		
Total TF Corr		

Aiming Post Df	2800	QE (Trial)	500.6	TF (Trial)	45.00
Df Correction	(L) R 10	QE Correction	+ (−) 19.4	TF Correction	+ (−) 1.86
DF (Corrected)	2810	QE (Corrected)	481.2	TF (Corrected)	43.1
Low Level Wind	(L) R 15	Low Level Wind	+ (−) 16.1	Fuze Corr	+ − ———
Df Fired	2825	QE Fired	465.1	FS Fired	43.1

** See FM 6-40-1A (Honest John/Little John)

Figure 3 ②. Computers record data correction sheet (for use with MGR-1A Rocket) (DA Form 2256-1-R).

(8) Compute and record the trial quadrant elevation and time flight (tables C and D).

(*a*) Trial quadrant elevation (QE)

	HOB		EL	
100	400	40	504	5
	340	X	?	
	300		499	

40/100 = X/5 or X = 2.0

Therefore the elevation at range 17,800 meters corresponding to HOB +340 meters = 499 + 2.0 = 501.0 mils. Obtain, the c factor (col. E3) at height +300, range 17,800 and determine the trial QE—

Trial QE = 501.0 — (10/100) 4.0 = 500.6

(*b*) Trial time of flight (TF)

	HOB		TF	
100	400	40	45.1	0.1
	340	X	?	
	300		45.0	

40/100 = X/0.1 or X = 0.04

Therefore the time of flight corresponding to range 17,800 meters, HOB +340 meters = 45.0 + 0.04 = 45.04 sec. Obtain the t factor (col. T3) at height + 300 meters, range 17,800 meters and determine the trial TF—

Trial TF = 45.04 — (10/100) 0.42 =45.00

(9) All MGR–1A firing tables are based on the Ordnance standard (US) metro and the ICAO atmosphere. Conversion of the NATO metro to the US format is required before continuing computations. Each firing table (or changes) contains the tables required for this conversion. The procedure using change 2 to FTR 762–F–1 is as follows:

(*a*) Enter table 1, change 2, with the trial QE 501 to determine the line number of the NATO metro message applicable to this problem. Line 05 is the indicated line.

(*b*) Line 05 of the NATO metro is—

05 27 23 039 957

(*c*) The wind direction, 2700 mils, from the NATO metro is used without conversion.

(*d*) The wind speed, 23 knots, must be converted to miles per hour. Enter table IV, change 2, to perform this conversion—

23 knots = 26 MPH

(*e*) To convert the ballistic air temperature percent of standard, 103.9 percent, of the NATO metro to degrees Fahrenheit, it must first be corrected for the difference in altitude of the launcher with reference to the MDP. The difference is —10 meters (360 —370 = —10 meters). Enter table II, change 2, with this difference. In this case, the air temperature correction is 0. Algebraically add the temperature correction to the air temperature percent of standard. The corrected value is 103.9 percent (103.9 + 0 = 103.9). Enter table V, change 2, to convert 103.9 percent of standard to degrees Fahrenheit.

103.9 percent = 79°F

(*f*) To correct the ballistic air density percent of standard, 95.7 percent, of the NATO metro, again enter table II, change 2, with the height of launcher with reference to the MDP (—10 meters). The air density correction is +0.1 percent. Algebraically add this correction to the air density percent of standard. The corrected value is 95.8 percent (95.7 + 0.1 = 95.8). No conversion is required because air density expressed in the NATO metro is based on the ICAO standard atmosphere.

(*g*) The converted line applicable to FTR 762–F–1 is—

05 27 26 95.8 79

(*h*) Since all MGR–1A firing tables are based on the Ordnance Standard (US) metro and the ICAO atmosphere, the surface air pressure of 1007 millibars measured with a barometer at the launcher does not require conversion to a percent of

standard surface air pressure. This value (1007) is entered in the appropriate space of the ballistic factors block of DA Form 2256-1-R. If a properly functioning barometer is not available, the procedure to be followed is explained in problem II.

(10) Compute the chart direction of the wind. Obtain the ballistic range and cross wind "correction" components (page 12). Compute the effective range and cross winds. Obtain the unit correction for a 1 MPH lateral ballistic wind (table A) and compute the cross wind correction.

(*a*) Chart direction of the wind—

Azimuth of wind (100 mils)	2700 mils
Plus 6400 mils (if necessary)	+6400 mils
Sum	9100 mils
Minus Azimuth of fire (100 mils)	—5000 mils
Equals chart direction of wind	4100 mils

(*b*) Wind "correction" components corresponding to 4100 mils—

Range wind	T.63
Cross wind	L.77

(*c*) Range wind

Range wind component	T.63
Multiplied by wind	×26 MPH
Equals Range Wind	T16 MPH

(*d*) Cross wind correction

Cross wind component	L.77
Multipled by wind velocity	×26 MPH
Equals cross wind	L.20 MPH
Multiplied by unit correction (table A)	×.44 mils
Equals cross wind correction	L9 mils

(11) Enter the known values for each ballistic factor and compute the variations from standard as follows:

Ballistic factors	Standard	Known	Variation from std
Propellant Temperature	77°F	80°F	Inc 3
Propellant Weight	2050 lbs	2049 lbs	Dec 1
Surface Pressure	1013 mb	1007 mb	Dec 6
Density	100%	95.8%	Dec 4.2
Air Temperature	59°F	79°F	Inc 20
Empty Weight	3850 lbs	3840 lbs	Dec 10
Range Wind	0 MPH	T16 MPH	T16

(12) Enter tables C and D, part 2, with the range and height of burst relative to the launcher to the nearest 100 meters and obtain the unit corrections to QE and TF for each variation from standard. Multiply the unit corrections by the variation and compute the algebraic sums of these products. These sums are the corrections to QE and TF for the nonstandard conditions of weather and materiel. The computations are as follows:

Ballistic factors	Variation from std	Unit corr to QE	+	−	Unit corr to TF	+	−
Propellant Temperature	D (I) 3	— .40		1.20	—.017		.051
Propellant Weight	(D) I 1	+ .44	.44		+.027	.027	
Surface Pressure	(D) I 6	— .069		.41	—.0043		.026
Density	(D) I 4.2	—3.52		14.78	—.288		1.210
Air Temperature	D (I) 20	+ .10	2.00		+.004	.080	
Empty Weight	(D) I 10	— .11		1.10	—.006		.060
Range Wind	H (T) 16	— .38		6.08	—.039		.624
Total Corrections			+2.44	—23.57		+.107	—1.971
				2.44			+ .107
Corr to QE and TF				—21.13			— 1.864

(13) Determine and record the rotation corrections to—

Deflection (Table B)	L1
Time of flight (Table F)	0 (.0 X .87)
Quadrant elevation (Table F)	+1.7 (+ 2 X .87)

(14) Compute the total corrections to deflection quadrant elevation and time of flight as follows:

Deflection	L	R	Quad elevation	+	—	Fuze setting	+	—
Df Corr (2d Traj)			Met Corr		21.1	Met Corr		1.86
Cross Wind Corr	9		Rotation Corr	1.7		Rotation Corr		0
Rotation Corr	1		Rail Align Corr			Rail Align Corr		
Rail Align Corr					1.7			
Total Df Corr	L10		Total QE Corr		—19.4	Total TF Corr		—1.86
Aiming Post Df		2800	QE (Trial)	500.6		TF (Trial)		45.00
				+			+	
Df Correction	Ⓛ	R 10	QE Correction	— 19.4		TF Correction	—	1.86
DF (Corrected)		2810	QE (Corrected)	481.2		TF (Corrected)		43.14

Note. No fuze correction is used with the MGR–1A rocket.

(15) Obtain the low-level wind components at X–2 min and compute the low-level range and cross wind corrections (normally computed in the firing section) as follows:

(*a*) The low-level wind components (assumed for this problem) are—

Cross wind	L2 MPH
Range wind	T6 MPH

(*b*) Low-level cross wind unit corrections determined from table E–2, change 1, corresponding to the corrected QE (481 to the nearest mil) are—

Cross wind (L)	7.35 mils
Range wind (T)	—2.68 mils

(*c*) Cross wind correction

Cross wind component	L2MPH
Multiplied by unit correction	X7.35 mils
Equals cross wind (DF) correction (to the nearest mil)	L15 mils (14.7)

Note. The direction to apply the correction is indicated by the direction of the wind component (left).

(*d*) Range wind

Range wind component	T6 MPH
Multiplied by Unit Correction	X—2.68 mils
Equals range wind (QE) correction (to the nearest 0.1 mil)	—16.1 mil

Note. The sign of the correction is indicated by the sign of the unit correction. Apply the computed low-level wind corrections to the corrected deflection quadrant elevation to determine firing data as follows:

DF (Corrected)	2810	QE (Corrected)	481.2
Low-level Wind	L15	Low-level Wind	—16.1
DF fired	2825	QE fired	465.1

Note. No low-level wind correction is applied to time of flight.

b. Problem II. If a properly functioning barometer is unavailable, the heading of the met message may be used to determine the surface air pressure.

Note. The appropriate tables for this situation are not contained in GMR–1A firing tables. However, tables appearing in MGR–1B firing tables are applicable and should be used. These tables are—

Table B, (air temperature, air density, and surface air pressure corrections).

Table C, (surface air pressure conversions).

Table D, (mean sea-level air pressure corrections).

(1) If the surface air pressure reported in the heading of a U. S. prepared NATO met message is referenced to the MDP, table B is entered with the height of launcher relative to the MDP (—10 meters) to obtain a correction of +0.1%. Assume the surface air pres-

sure reported in the heading of the U. S. prepared NATO met message is 98.6% at the MDP. MDP surface air pressure + surface air pressure correction for launcher height relative to the MDP = surface air pressure at launcher altitude, or 98.6 + (+0.1) = 98.7%. Table C of the MGR–1B firing table is entered to convert the surface air pressure expressed as a percent of standard to millibars. (98.7% = 1000 millibars). This value is then entered in the correct space of the ballistic factors block.

(2) If the surface air pressure reported in the heading of the U.S. prepared NATO met message is referenced to mean sea level, table D of the MGR–1B firing table is entered with the altitude of the launcher to the nearest 10 meters (360 meters) to obtain a correction of —4.3%. Assume the surface air pressure reported in the heading of the U.S. prepared NATO met message is 102.7%.

MSL surface air pressure + surface air pressure correction for launcher altitude = surface air pressure at launcher altitude; or 102.7% + (—4.3%) = 98.4%.

Table C of the MGR–1B firing tables is entered to convert the surface air pressure expressed as a percent of standard to millibars (98.4% = 997 mb). This value is then entered in the correct space of the ballistic factors block.

c. If a properly functioning windset is not available, a pilot balloon technique may be used to determine low-level winds. The procedures for this method are discussed in paragraph 37. If neither the windset nor pilot balloon is available, line 0 of the met message may be used in the same manner as that discussed for the MGR–1B rocket (para. 20*d*).

Section IV. SAMPLE MISSION—MGR–3A ROCKET

23. Computation of Firing Data

The procedure to be used in the computation of firing data is illustrated in the example below.

a. Problem I. In this example, the propellant temperature is in the range 77°F to 0°F and low-level wind data are obtained with the wind measuring set AN/PMQ–6. The round is to be fired during NIGHTTIME CONDITIONS. FTR 318–A–1 is applicable in this example. DA Form 6–56 is conveniently arranged in a logical sequence for computations starting at the top left corner of the form and working across and down.

(1) The following fire mission is received in the FDC:
THIS IS RAMROD 3
FIRE MISSION
ROCKET MGR–3A
WARHEAD M8
COORDINATES OF TARGET WX-1375386384
ALTITUDE of TARGET 1302 METERS
HEIGHT OF BURST ABOVE TARGET 200 METERS
1 LAUNCHER
1 ROUND
TIME ON TARGET 0445
CONCENTRATION EG 104

(2) The S3 issues the following fire order:
LAUNCHER NUMBER 3
FIRING POSITION NUMBER 5
CONCENTRATION EG 104

(3) Based on the information received from the fire mission and the fire order, the following warning order is sent to the firing section:
LAUNCHER NUMBER 3
FIRING POSITION NUMBER 5
ROCKET MGR–3A
WARHEAD M8
ONE ROUND AT MY COMMAND
TIME ON TARGET 0445

(4) All known values are entered on the Computers Record and Data Correction Sheet (DA Form 6–56, fig. 4 ① and ②).
(*a*) Target coordinates WX1475386384
(*b*) Target altitude 1302 meters
(*c*) Launcher coordinates WX058649-7009
(*d*) Launcher altitude 1256 meters
(*e*) Azimuth of orienting line 312 mils
(*f*) Empty weight 541 pounds
(*g*) Propellant weight correction —0.2 pounds
(*h*) Propellant temperature 62°F
(*i*) Surface air pressure (barometer) 902 millibars
(*j*) Latitude of launcher 34°N

COMPUTERS RECORD AND DATA CORRECTION SHEET (FREE ROCKET)

UNIT	Lchr Lat (N) S	Time and Date Fired	Min	FPC 195 ø	Conc Nr EG 104
1/85	34	0445 2APR64	QE	FDC 201 ø	Rkt Mtr SN 26315

FIRE MISSION

RAMROO 3, FM,
Type Rkt M6R-3A Whd M-8,
Lchr Nr ____, FP Nr ____,
Tgt Coord WX 13753 86384
Tgt Alt 1302 m, Rel Tgt HOB** 200 m
Fuze ( ) Air HOB**( ) High
Opt ( ) Impact Opt ( ) Low
Lchr(s) to Fire 1, Nr Rkts to Fire 1,
~~Pred Time~~ (TOT) ~~of Fire~~ 0445 Conc Nr EG 104

FIRE ORDER

Lchr Nr 3 FP Nr 5
Conc Nr EG 104

WARNING ORDER

Lchr Nr 3, FP Nr 5,
Type Rkt M6R-3A, Whd M8,
Fuze ( ) Air HOB ( ) High
Opt ( ) Impact Opt ( ) Low
Method of Fire (1) AMC
~~Pred Time~~ TOT 0445

COMPUTATION OF RANGE AND BEARING

Tgt Coord	13753	86384
Lchr Coord	05864	97009
	dE 7889	dN 10625

dE- dN+ 6400 - Bearing | dE+ dN+ 0 + Bearing
dE- dN- 3200 + Bearing | dE+ dN- 3200 -Bearing

BEARING

Log dE	3.897022
Log dN	- 4.026329
Log Tan Bearing	9.870693
Bearing	650.6 ø

AZIMUTH

0 3200 6400: 3200 ø
Bearing 651 ø
Az of Fire 2549 ø

RANGE

dE Greater than dN

Log dE	
Log Sin B	-
Log Rg	
Range	m

dN Greater than dE

Log dN	4.026329
Log Cos B	- 9.904638
Log Rg	4.121691
Range	13,234 m

Computation** Range (10m) 13,230 m

HOB REL TO LCHR

Tgt Alt	1302 m
HOB rel to Tgt**	+ 200 m
Alt of Burst	= 1502 m
Alt of Lchr	- 1256 m
HOB rel to Lchr	= + 246 m
HOB rel to Lchr (10m)	250 m

SECOND TRAJECTORY COMPUTATIONS

Alt Tgt		m
Alt Lchr		m
Ht of Tgt rel Lchr	±	m
H_B		m
Ht Tgt rel Lchr	-	m
HOB above Tgt	+	m
Wind Az (100ø)		ø
+6400 (if nec)	+	ø
Sum	=	ø
Az of Fire (100ø)	-	ø
Chart Dir of Wind	=	ø

Computations: (R_B (Trial) and H_B)

MET CORRECTIONS

Line Nr	Wind Az	Wind Vel	Temperature	Density

Alt Tgt ____ m — Density Correction
Alt MDP - ____ m
Alt Diff ____ m — Corrected Value

Ballistic Factors	Known	Std	Var fr Std	Unit Corr	+/-
Density		100%	D I		
Rg Wind		0 Kn	H T		
Met Corr to R_B (Trial)					

R_B	
R_B (Trial)	m
Met Corr to R_B	+ - m
R_B (Corr)	m

RANGE H ____ H
WIND T ____ (Comp) X ____ (Vel) = T ____ Knots

CROSS L ____ L ____ L
WIND R ____ (Comp) X ____ (Vel) = R ____ X ____ (Unit Corr) = R ____ ø

**See FM 6-40-1A (Honest John/Little John)

DA, FORM 1 JUL 61 6-56

Figure 4 ①. Computers record and data correction sheet (Free Rocket) (DA Form 6-56).

Firing Table Entry Range (Computation Range or $^{R}_{B}$ (Corr)) 13,230 m

Firing Table Entry Height of Burst (HOB rel to Lchr (10 m) or H_B) +250 m

Alt of Lchr 1256 m | Az of Fire 2549 ‰

Latitude of Lchr (10°) 30 (N)/S | Df Corr (2d Traj) L / R ____ ‰

Initial Laying Data*	
*Az of OL	312 ‰
+6400 (if nec)	+6400 ‰
Sum	=6712 ‰
*Az of Fire	-2549 ‰
Difference	=4163 ‰
~~3200 (if nec)~~	- ‰
*Orienting Angle	=4163 ‰
*QE (Trial)	312 ‰
Alt Lchr (10m)	1260 m
Alt MDP (10m)	-1050 m
Lchr (above)/below MDP	+ 210 m
Az of Wind (100‰)	2600 ‰
+ 6400 (if nec)	+ ____ ‰
Sum	=2600 ‰
Az of Fire (100‰)	- 2500 ‰
Chart Dir of Wind	= 100 ‰

Computations (QE (Trial), TF (Trial), and Surface Pressure):

QE.

307.4 + (50/100) 7.6 = 307.4 + 3.8 = 311.2

311.2 + (30/100) 3.7 = 311.2 + 1.1 = 312.3

TF

31.36 + (50/100) 0.2 = 31.36 + 0.01 = 31.37

31.37 + (30/100) .38 = 31.37 + 0.11 = 31.48

SP

902 mb CORRESPONDS TO 89.0% OF STD.

Met Station	Use	Type	Oct	Latitude			Longitude		
M E T	S	3	1	3	4	4	9	8	3

Day		B. Time		E. Time		Altitude MDP			Sur. Press. (SL)		
1	2	1	0	1	2	1	0	5	9	1	5

Line Nr		Wind Az		Wind Vel		Temperature			Density		
0	4	2	6	2	0	0	3	9	9	5	6
Temperature-Density Corr						-	0	5	-	2	1
Corrected Values						1	0	3	4	9	3	6

RANGE WIND (H) T .99 Comp X 20 Vel = (H) T 20 Knots

CROSS WIND L (R) .10 Comp X 20 Vel = L (R) 2 X .47 Unit Corr = L (R) 1 ‰

BALLISTIC FACTORS	Std	Known	Variation from Std	Unit Corr to QE	+	-	Unit Corr to TF	+	-
Propellant Temperature	____ ° Decrease / 77°F	62	(D) I 15	+ .10	1.50		+ .005	.075	
Propellant Wt	lb		(D) I .2	+ 2.41	.48		+ .140	.028	
Surface Pressure	100%	89.0	(D) I 11.0	- .32		3.52	- .019		.209
Density	100%	93.5	(D) I 6.5	- 2.30		14.95	- .178		1.157
Air Temperature	100%	103.4	D (I) 3.4	+ .47	1.60		+ .018	.061	
Empty Weight	536 lb	541	D (I) 5	+ .61	3.05		+ .029	.145	
Range Wind	0 Knots	H20	(H) T 20	+ .36	7.20		+ .036	.720	
					13.83	18.47		1.029	1.366
Met Corr to QE and TF						13.83			1.029
						4.64			.337

DEFLECTION	L	R	QUAD ELEVATION	+	-	FUZE SETTING	+	-
Df Corr (2d Traj)	____	____	Met Corr		4.6	Met Corr		.34
Cross Wind Corr		1	Rotation Corr		.9	Rotation Corr		0
Rotation Corr	1		Rail Aline Corr			Rail Aline Corr		
Drift Corr								
Rail Aline Corr								
	1							
	-1							
Total Df Corr	0		Total QE Corr		5.5	Total TF Corr		.34
Aiming Post Df	2800		QE (Trial)		312.3	TF (Trial)		31.48
Df Correction	L R ____		QE Correction (±)		5.5	TF Correction (±)		.34
Df (Corrected)	2800		QE (Corrected)		306.8	TF (Corrected)		31.1
Low Level Wind	L (R)	7	Low Level Wind (±)		4.7	Fuze Corr (±)		0.2
Df Fired	2793		QE Fired		311.5	FS Fired		31.3

Figure 4 (2). Computers record and data correction sheet (Free Rocket) (DA Form 6-56).

(5) The following NATO metro message is received:

MET S31	344983
121012	105915
USL	
002309	029957
012215	029956
022318	033954
032419	039954
042620	039956
052822	050957

(6) Compute and record:

(*a*) *The bearing.* In the block "Computation of Range and Bearing," enter the coordinates of the launcher and target. In this example, since the launcher coordinates for easting are smaller than those for the target, it is readily seen that the launcher is located west of the target. By the same reasoning, since the launcher coordinates for northing are larger than those for the target, it can be seen that the launcher is north of the target. Therefore, the direction of fire will be southeast. For convenience in remembering, draw an arrow in the second quadrant of the bearing block in the upper right hand corner. (This corresponds to a + dE and a —dN.) In the block labeled "Bearing", obtain the logarithmic values of dE and dN from the logarithm tables (TM 6–230) and determine the difference. This is the log tangent of the bearing. The antilog of this gives the bearing (650.6m).

(*b*) *Azimuth of fire.* Enter the bearing obtained above to the nearest mil (651m) in the appropriate space in the azimuth block at the right hand side of DA Form 6–56. Since the bearing is in the second quadrant, subtract it from 3200 mils to obtain the azimuth of fire (2549m).

(*c*) *Launcher-target range.* First determine which is greater, dE or dN, and enter the values obtained from the log table on the appropriate lines of the "Range" block. After the range is computed (13234 meters), enter this value in the "Computation Range" block immediately below to the nearest 10 meters (13,230 meters).

(*d*) *Height of burst relative to launcher.* In the HOB REL TO LCHR block, enter the target altitude (1302 meters) and the HOB relative to the target (200 meters). This information is obtained from the FIRE MISSION block. Add these two values to obtain the altitude of the burst (1502 meters). From the altitude of the burst, subtract the altitude of the launcher (1256 meters) to obtain the height of burst relative to the launcher (+246 meters). Record this value in the space provided to the nearest 10 meters (+250 meters).

(*e*) *Computations on reverse of form.* Since this example does not include second trajectory computations, the remainder of the problem will be computed on the reverse side of the form. At the top of the form on the reverse side, enter the Firing Table Entry Range (computation range) (13,230 meters); Firing Table Entry Height of Burst (+250 meters); altitude of launcher (1256 meters), azimuth of fire (2549 mils); and latitude of launcher to nearest 10° (30°N). These values are obtained from the computations performed on the front side of the form.

(*f*) *Value of orienting angle.* In the "Initial Laying Data" block enter the azimuth of the orienting line (312 mils), subtract the azimuth of fire (2549 mils) adding 6,400 mils as necessary and obtain the value of the orienting angle (4163 mils).

(7) Trial QE is determined by entering Table C of FTR 318–A–1 with the range to the nearest 100 meters and obtaining the elevation from column E2 corresponding to the firing table entry Height of Burst in column E1.

(*a*) In this example, to obtain the ele-

vation (column E2) corresponding to the launcher-target range of 13,230 meters, entry to the firing table is made at range 13,200 meters and HOB relative to launcher of +250 meters (column E1). To do this, interpolation is necessary between +200 meters and +300 meters HOB as follows:

	HOB		*EL*	
	300		315.0	
100	250	50	X ?	7.6
	200		307.4	

$$\frac{50}{100}\ \frac{X}{7.6} \text{ or } X = 7.6\ \left(\frac{50}{100}\right) = 3.8$$

Therefore, the elevation corresponding to HOB of +250 meters and range 13,200 meters = 307.4 + 3.8 = 311.2 mils.

(*b*) Since this value was obtained at an entry range of 13,200 meters, computation must still be made for the additional 30 meters of range. This is accomplished by using the c factor found in column E3 of the same table. Entry is made to the nearest 100 meters HOB (+200).

Note. When the entry height of burst falls exactly between two listed values as it does in this case, the computed HOB to the nearest meter (+246) indicates the entry value (+200).

The corresponding c factor (+3.7) is obtained. This factor represents the number of mils in elevation necessary to change the range 100 meters. The addition of 30 meters in range is required and is computed as follows: 30/100 X 3.7 = 1.11 or 1.1 mils. Add this value to the elevation already computed for range 13,200 meters and HOB + 250 meters (311.2 mils) and obtain the trial QE of 312.3 mils (311.2 + 1.1 = 312.3). This value is entered in the bottom space of the initial laying data block to the nearest mil and in the QE (Trial) space at the bottom center of the form to the nearest tenth mil.

(*c*) Transmit initial laying data to the firing section.

1. Azimuth of the orienting line 312 mils
2. Azimuth of fire 2549 mils
3. Orienting angle 4163 mils
4. Trial QE 312 mils

(Each element of the initial laying data is transmitted to the firing section as soon as it is obtained to preclude any delays at the firing section.)

(*d*) Trial time of flight (TF) is determined in the same manner as trial QE. Entry to table D of the firing table is made using the same range (13,200) and HOB (+250). Time of flight corresponding to 13,200 meters is determined by interpolation as follows:

	HOB		*TF*	
	200		31.36	
100	250	50	X ?	0.02
	300		31.38	

$$\frac{50}{100} = \frac{X}{0.02} \text{ or } X = 0.02\ \left(\frac{50}{100}\right) = 0.01$$

Therefore, the time of flight corresponding to HOB +250 meters and range 13,200 meters is 31.37 seconds (31.36 + 0.01 = 31.37).

(*e*) As with the trial QE, computation must be made for the additional 30 meters of range beyond 13,200 meters. This is accomplished by using the f factor found in column T3 of table D. Entry is made to the nearest 100 meter HOB (+200) and the corresponding t factor of .38 is obtained. The correction is computed as follows: 30/100 × .38 = .114 or .11 seconds. This value is added to the time of flight computed in (*d*) above (31.37) and the trial time of flight of 31.48 seconds (31.47 + .11 = 31.48) is obtained. This value is not sent to the firing section, but is entered in the TF (TRIAL) space at the lower right hand corner of the form.

Note. The blank space on the reverse side of DA Form 6-56 is for use in computing Trial QE and TF.

(8) The Trial QE having been determined,

it is now possible to find and reduce the data of the met message to a form that can be used in computing the corrections to trial QE, trial TF, and deflection for nonstandard meteorological conditions.

(*a*) Enter the values from the heading of the met message in the appropriate spaces on the form.

(*b*) Enter the "line number of NATO meteorological message" table (page 12) with the trial QE, 312 mils, and determine the line number applicable to this particular fire mission. This indicated line number is 04.

(*c*) The data for line 04 (uncorrected for the difference in altitudes of the launcher and MDP) are—

04 26 20 103.9 95.6

Enter these data in the appropriate spaces on the form.

(*d*) Since temperature and density vary appreciably with altitude, corrections must be made to compensate for the difference in altitude of the launcher and the MDP. To accomplish this, first obtain the difference in altitude of the launcher and the MDP using the space at the left side of the form directly beneath the trial QE block.

Altitude of launcher (1256 to the nearest 10 meters)	1260 meters
Minus the altitude of MDP	—1050 meters
Difference (launcher above MDP)	+ 210 meters

Enter the "air density and air temperature correction" table (page 11) at the height of launcher with reference to MDP (+210 meters) to obtain a correction to air temperature of —0.5 percent and a correction to air density of —2.1 percent. Apply these corrections to the air temperature and density recorded from line 04 of the met message.

	TEMPERATURE	*DENSITY*
	103.9	95.6
	— 0.5	— 2.1
CORRECTED	103.4	93.5

Line 04 of the met message (corrected) now reads:

04 26 20 103.4 93.5

Enter these values in the appropriate spaces provided on the form.

(9) Convert the surface air pressure measured with a barometer at the firing position (902 millibars) to a percent of standard air pressure. Enter the Surface Air Pressure conversion table, change 1, with 902 millibars to obtain 89.0 percent.

Note. Surface air pressure in millibars may be converted to a percent of standard as follows:

$$\frac{\text{Surface air pressure in millibars}}{\text{1013 millibars}} \times 100 = \text{percent of standard}$$

Example.

$$\frac{\text{902 millibars}}{\text{1013 millibars}} \times 100 = 89.0 \text{ percent}$$

Note. If the surface air pressure from a barometer is unavailable, the surface air pressure from the heading of the metro message may be used. This value is less accurate than that taken with a barometer at the firing position and should be used only when necessary. The surface air pressure of the metro message may be either the value at the MDP or at mean sea level (MSL). The procedures for using these values are outlined in problem III and IV.

(10) The met message is now applicable to the firing problem being solved; but, before actual corrections can be made for existing meteorological conditions, the ballistic wind data must be reduced to cross wind and range wind components. Obtain the chart direction of the ballistic wind by subtracting the azimuth of fire from the azimuth of the ballistic wind. This procedure yields—

Azimuth of ballistic wind 2600‰
Azimuth of fire (2549 to nearest 100m) —2500‰

Chart direction of ballistic wind = 100‰

Using this chart direction of wind, enter the "Correction components of a unit wind" table (page 8) to obtain:

Range wind correction component = H .99

Cross wind correction component = R .10

The ballistic cross and range winds are the products of the wind velocity from line 04 of the met message (20 knots) and the correction components just determined.

Hence,

Ballistic range wind = H .99 × 20 = H20 knots

Ballistic cross wind = R .10 × 20 = R2 knots

(11) A correction to deflection must be made to compensate for the ballistic cross wind. Determine the unit correction factor for a ballistic cross wind of 1 knot from table A, column 11. Enter table A at the nearest listed range (13,000 meters) and find a factor of .47‰. The correction for a cross wind of R2 is: R2 × .47 = R1‰.

(12) Corrections to QE and TF must be made to compensate for nonstandard conditions of materiel and weather.

(*a*) First, compute variations from standard of all metro and ammunition data and enter the variation from standard in the appropriate column of the BALLISTIC FACTORS block of the form as shown below:

Ballistic factors	Standard	Known	Variation from std
Propellant Temperature	77°F	62°F	Dec 15
Propellant Weight	lbs	—.2	Dec .2
Surface Pressure	100%	89.0%	Dec 11.0
Density	100%	93.5%	Dec 6.5
Air Temperature	100%	103.4%	Inc 3.4
Empty Weight	536 lbs	541 lbs	Inc 5
Range Wind	0 knots	H 20 knots	HEAD 20

(*b*) Next, determine the unit corrections to QE and TF by entering tables C and D at range 13,200 meters and height 200 meters. The column chosen to obtain unit corrections for variation from standard conditions is dependent on whether or not the variation is an *increase* or *decrease*.

(*c*) Finally, the unit correction factors obtained in (*b*) above are multiplied by the variations from standard (*a*) above and summed algebraically to find the total corrections to QE and TF. Sample computations are as follows:

Ballistic factors	Variations from std	Unit correction to QE	Total correction +	Total correction −	Unit correction to TF	Total correction +	Total correction −
Propellant Temperature	(D) I 15	+ .10	1.50		+.005	.075	
Propellant Weight	(D) I .2	+2.41	.48		+.140	.028	
Surface Pressure	(D) I 11.0	— .32		3.52	—.019		.209
Density	(D) I 6.5	—2.30		14.95	—.178		1.157
Air Temperature	D (I) 3.4	+ .47	1.60		+.018	.061	
Empty Weight	D (I) 5	+ .61	3.05		+.029	.145	
Range Wind	(H) T 20	+ .36	7.20		+.036	.720	
Total Corrections			+13.83	—18.47		+1.029	—1.366
				+13.83			+1.029
Corr to QE and TF				4.64			.337

Enter met corrections above obtained in the appropriate spaces immediately below and in the proper column (+ or —). The correction to QE (—4.64) is entered to the nearest tenth mil (—4.6) and the correction to TF (—.337) is entered to the nearest hundreth second (—.34).

(13) Corrections to deflection must be made to compensate for rotation of the earth.

(*a*) Table B is entered with the latitude to the nearest 10° (30° N); azimuth of fire to the nearest 400 mils (in this case 2400 mils); and range to the nearest 2,000 meters (13,000). The correction for rotation of earth is L 1~~mil~~.

(*b*) Assuming an aiming point deflection of 2800 mils and combining the correction for a cross wind (R 1~~mil~~) obtained in subparagraph (11) above and the corrections for rotation of the earth (L 1~~mil~~), the corrected deflection is 2800 — 1 + 1 = 2800~~mil~~.

Note. The standard rule for deflection applies: left—add; right—subtract.

(14) To adjust QE and TF for rotation of the earth corrections are first found for the launcher-target range and azimuth of fire at 0° latitude and then multiplied by a factor in order to convert them to corrections for the latitude of the launcher. These corrections are found by entering Table E at range 13,000 meters and azimuth 2600**m**. The Corrections are—

QE correction at 0° latitude = —1~~mil~~

TF correction at 0° latitude = 0 sec.

Correction factor at 30°N latitude = .87 (from table under table E).

Therefore, the corrections for rotation to QE and TF are—

QE correction = —1~~mil~~ × .87 = —.9~~mil~~

TF correction = 0 sec × .87 = 0 sec.

(15) The total corrections to QE and TF are the sums of the met corrections and the corrections for rotation. Thus, Total QE correction = —4.6 (met correction) + (—.9) (rotation correction) = —5.5~~mil~~. Total TF correction = —.34 (met correction) + 0 (rotation correction) = —.34 second. Adding these corrections to the trial QE and the trial TF gives—

Corrected QE = 312.3~~mil~~ —5.5~~mil~~ = 306.8~~mil~~

Corrected TF = 31.48 sec. — .34 sec = 31.1 seconds

(16) A correction to TF must be made to compensate for a bias in the M421 fuze. This is found in Table F and yields a fuze correction of +.2 second. Adding this to the corrected TF results in a fuze setting fired of 31.3 seconds (31.1 seconds + .2 = 31.3 seconds). The fire commands can now be sent to the firing section. These are—

Deflection	2800 mils
Time	31.3 seconds
Quadrant elevation	306.8 mils

(17) Corrections to deflection and QE must be made to compensate for low-level winds and may be determined by the firing section leader at the firing position or at FDC. These computations are normally made approximately 2 minutes prior to firing. Conditions are all other than NIGHTTIME. The cross wind and range wind are obtained from the wind speed indicator of the wind measuring set. The readings are—

Cross wind = R 5 MPH

Range wind = H 13 MPH

(*a*) The deflection and range correction factors are found by entering table G-1, change 2, with the corrected QE to the nearest mil (307~~mil~~).

Note. For NIGHTTIME conditions table G-2 would be entered.

The products of these factors and the cross wind and range wind give the deflection and range corrections.

(*b*) By interpolation, for QE 307~~mil~~, Table G-1 gives a deflection cor-

rection factor of 1.38. Deflection correction = 1.38 × R5 = R6.90 = R7 to the nearest mil.

(*c*) By interpolation, for QE 307mils, Table G-1 gives a QE correction factor of +.36. QE correction = +.36 XH13 = H4.7mils.

Note. No low-level wind correction is applied to time of flight.

(*d*) The deflection fired and the QE fired are obtained by adding the low-level wind corrections to the corrected deflection and corrected QE.

Deflection fired = 2800 — 7 = 2793mils
QE fired = 306.8mils + 4.7mils = 311.5mils

b. Problem II.

Note. Values in this problem have no relation to value computed in previous problems.

For computation of firing data involving propellant temperature in the range of 0°F to —40°F, the corrections must be computed as follows:

(1) From columns E5 of table C and T5 of table D (FTR 318-A-1) the corrections to QE and TF to compensate for the total 77°F decrease in propellant temperature from 77°F to 0° are obtained.

(2) From columns E6 and T6 of the same tables the unit corrections applicable in the range 0°F to —40°F are found. These are used in the usual manner to obtain corrections for the decrease in propellant temperature from 0°F to the observed temperature.

(3) The sums of the QE and TF corrections obtained above are the total corrections for the decrease from 77°F to the observed temperature.

(4) As an example of the procedure just outlined, assume a firing is to be conducted with a propellant temperature of —15°F. Range is 16,244 meters and height of 266 meters. By following the steps in (1), (2), and (3) above, this yields —

	QE	*TF*
Corrections for 77°F decrease (77°F to 0°F).	11.0 mils	0.55 sec
Corrections for 15°F decrease (15 x .25) (0°F to —15°F).	3.75 mils (15 x 0.010)	0.150 sec
Corrections for 92°F decrease (77°F to —15°F).	14.75 mils	0.700 sec

Corrections for other nonstandard conditions are computed as outlined in *a* above.

c. Problem III. If a properly functioning wind set is not available, a pilot balloon technique (para. 37) may be used to determine low-level winds. If neither the wind set nor the pilot balloon is available, line 00 of the metro message may be used to determine low-level winds. The chart direction of the wind is determined as in paragraph *a* above except that the wind direction (azimuth) from line 00 is used. For the metro message given in that problem, the chart direction of the wind is 6200 mils. Using this chart direction of the wind, enter the "Correction" component table (of a unit wind) and obtain —

Range wind "correction" component = H.98

Cross wind "correction" component = R.20

The line 0 wind velocity is 9 knots. This velocity must be converted to MPH. The appropriate factor for this conversion is 1.1508.

9 knots x 1.1503 = 10 MPH

Thus, the range and cross components of the low-level wind are

10 × H.98 = H 10 MPH
10 × R.20 = R 2 MPH

Finally, the QE and Df corrections are found by forming the product of these low-level wind components and appropriate correction factors from table G FTR 318-A-1 (or wind card FTR 318-A-1 G-3) with an assumed corrected QE 324. These final corrections are—

QE correction = 10 × .35 = 4~~M~~
Deflection correction = R2 × 1.26 = R 3~~M~~

d. Problem IV. If surface air pressure measured with a barometer at the firing position is not available, the surface air pressure from the heading of the met message may be used. This value may be the percent of standard surface air pressure at the MDP reduced to mean sea level (MSL) or it may be the percent of standard surface air pressure as measured at the MDP. In either case a correction to the indicated pressure must be made to determine the percent of standard surface air pressure at the firing position (launcher). This correction is computed utilizing a variation in air pressure of 1.2 percent of standard per 100 meters change in altitude. As altitude increases, air pressure decreases and as altitude decreases, air pressure increases.

Note. The surface air pressure correction table in FTR 318-A-1 is based on a height-temperature relationship and is *not* used in these computations.

(1) If the surface air pressure in the heading of the met message is expressed at MSL, the correction applied to it is based on the height of the launcher with respect to MSL. Multiply —1.2 percent by the height of the launcher with respect to MSL in hundreds of meters to the nearest 10 meters. If the launcher is above MSL the correction is minus; if the launcher is below MSL the correction is plus.

Example:

(*a*) Known conditions:
Surface air pressure (MSL) 100.3 percent
Altitude of launcher 446 meters

(*b*) Compute the change in air pressure as follows:

$$\frac{450}{100} \times -1.2 = -5.4 \text{ percent}$$

(*c*) Apply this change to the indicated MSL surface air pressure to obtain the surface air pressure at the launcher.
100.3 + (—5.4) = 94.9 percent

(2) If the surface air pressure in the heading of the met message is expressed at the MDP, the correction applied to it is based on the height of the launcher with respect to the MDP. Multiply —1.2 percent by the height of the launcher with respect to the MDP in hundreds of meters to the nearest 10 meters. If the launcher is above the MDP the correction is minus; if the launcher is below the MDP the correction is plus.

Example:

(*a*) Known conditions:
Surface air pressure (MDP) 97.6 percent
Altitude of MDP 420 meters
Altitude of launcher 312 meters

(*b*) Compute the change in air pressure as follows:

$$\frac{(310 - -420)}{100} \times -1.2 =$$

(—1.1) × (—1.2) = +1.3

(*c*) Apply this change to the indicated MDP surface air pressure to obtain the surface air pressure at the launcher.
97.6 + (+1.3) = 98.9 percent

e. Problem V. If, in problem I, the range had been 13,170 instead of 13,230, then tables C and D would have been entered with the value of 13,200 meters and the firing table values for QE, TF, c and t would have been the same. However, the trial QE and TF would have been determined by applying the c and t factors in the opposite direction. Thus, for a range of 13,170 meters, trial QE and trial TF would have been determined as follows:

$$\text{Trial QE} = \underline{311.2} - 30/100 \times 3.7 =$$
310.1 mils

$$\text{Trial TF} = \underline{31.37} - 30/100 \times .38 =$$
31.26 seconds

CHAPTER 4
DETERMINATION OF MINIMUM QUADRANT ELEVATION AND CREST CLEARANCE FOR HONEST JOHN AND LITTLE JOHN

24. Determination of Minimum Elevation

To determine the final minimum elevation for the HONEST JOHN/LITTLE JOHN rocket system, two areas of consideration are involved.

a. Firing Platoon (Section) Commander's minimum elevation.

b. Fire Direction Center minimum elevation.

25. Firing Platoon (Section) Commander's Minimum Quadrant Elevation

a. General. The firing platoon (section) commander (FPC) must compute the position-launcher-rocket minimum quadrant elevation (QE) and report it to the FDC. To determine this minimum QE, it is necessary to consider three factors—

(1) Rocket Qualification Quadrant Elevation.
(2) Launcher-Beam Separation Angle.
(3) Launcher Emplacement Angle.

b. Rocket Qualification Quadrant Elevation. The rocket qualification QE is the lowest QE for which safe results may be obtained when firing a particular rocket. This restriction is imposed by the necessity of overcoming the force of gravity and varies with the mass of the rocket and the thrust developed by the rocket. *It is independent of the launcher position or launcher used.* Regardless of any other factor, a rocket may *never* be fired at a QE less than the qualification QE for that rocket. The qualification QE for each rocket is—

Rocket	*Qualification Quadrant Elevation*
MGR–1A	178 mils
MGR–1B	71 mils
MGR–3A	71 mils

c. Launcher-Beam Separation Angle. The launcher-beam separation angle is that minimum angle which may be formed between the longitudinal axis of the launcher bottom carriage and the launcher rail (beam) to allow full traverse capabilities and insure that the complete rocket will safely clear any part of the launcher when fired. This angle is dependent upon the launcher and rocket configurations. It varies with each launcher-rocket combination. The launcher-beam separation angle for each combination is—

LAUNCHER	*ROCKET*	*LAUNCHER-BEAM SEPARATION ANGLE*
M289	MGR–1A	213 mils
	MGR–1B	213 mils
M386	MGR–1A	107 mils
	MGR–1B	53 mils
M33	MGR–1A	178 mils
	MGR–1B	71 mils
M34	MGR–3A	0 mil

d. Launcher Emplacement Angle. The launcher emplacement angle is that angle from the horizontal plane imposed by emplacing the launcher on either a forward or a reverse slope. The maximum emplacement angle for all launchers is ± 178 mils (reverse slope +178 mils and forward slope —178 mils). The actual emplacement angle for all launchers except the M289 is determined by measuring the elevation of the launcher rail when it is locked in the traveling position. For the M289 launcher, the launcher rail is separated from the truck chassis by 88 mils when locked in the traveling position. To determine the emplacement angle for the M289 launcher, measure the beam elevation with the launcher emplaced and the beam locked in the traveling position and algebraically add —88 mils to the measured beam elevation. The sum is the launcher emplacement angle.

Example:

Measured Beam Elevation	+30 mils
Plus Traveling Position Separation	+(—)88 mils
Equals Launcher Emplacement Angle	—58 mils

e. Determination of Firing Platoon (Section) Commander's Minimum Quadrant Elevation. To determine the firing platoon (section) commander's minimum quadrant elevation (MIN QE FPC), the procedure is as follows:

(1) Determine the emplacement angle.

(2) Algebraically add the launcher-beam separation angle of the particular launcher-rocket combination to the emplacement angle. This sum is the minimum QE which will allow full traverse capability and insure that no part of the launcher will interfere with the movement of the rocket along the rail.

(3) Compare the sum obtained in (2) above with the qualification QE of the rocket to be fired. The larger positive (+) value of the two is the minimum quadrant elevation for that position-launcher-rocket combination and is reported to the FDC as the firing section commander's minimum quadrant elevation.

Example:

(*a*) Known conditions—

Launcher	M386
Rocket	MGR-1A

(*b*) Measure an record the emplacement angle _____35 mils

(*c*) Determine the launcher-beam separation angle for the M386 launcher firing the MGR-1A rocket (*c* above) +107 mils

(*d*) Algebraically add the launcher-beam separation angle to the emplacement angle.

Emplacement angle ____	—35 mils
Plus Launcher-Beam Separation Angle___	+(+)107 mils
Algebraic Sum ____	+72 mils

(*e*) Determine the rocket qualification angle for MGR-1A rockets (*b* above) _____ +178 mils

(*f*) Compare the algebraic sum obtained in (*d*) above (+72 mils) with the qualification QE (+178 mils). The qualification QE of +178 mils is the greater positive value and is reported to the FDC as the firing platoon commander's minimum quadrant elevation.

f. Piece Mask Data. In addition to computing and reporting the position-launcher-rocket minimum quadrant elevation, the firing platoon commander must also report the measured angle of site to mask and the piece mask range to FDC. The piece mask is defined as the highest crest in front of the firing position visible from the firing position. The range to mask may be determined from a map or estimated.

26. Fire Direction Center Minimum Quadrant Elevation

a. General. The S3 is responsible for establishing the FDC minimum quadrant elevation (MIN QE FDC). This value is the quadrant elevation which gives the maximum assurance of clearing the piece mask, all immediate crests and the no-fire line. To determine this quadrant elevation, it is first necessary to compute the—

(1) Piece mask minimum quadrant elevation.

(2) Intermediate crest(s) minimum quadrant elevation(s).

(3) No-fire line minimum quadrant elevation.

Once these values have been computed and compared, the largest value is selected and recorded as the FDC minimum quadrant elevation.

b. Piece Mask Minimum Quadrant Elevation. The computation of piece mask minimum quadrant elevation is the responsibility of the S3 and is accomplished in the FDC based upon the piece mask data reported by the firing platoon commander (para. 25*f*). If the piece mask range is other than a whole thousand meters, it is increased to the next higher thousand meters for use in these computations. Four factors, expressed as angles, are added together to produce the piece mask minimum quadrant elevation (fig. 6): angle of site to mask, 60 meters vertical clearance at the mask converted

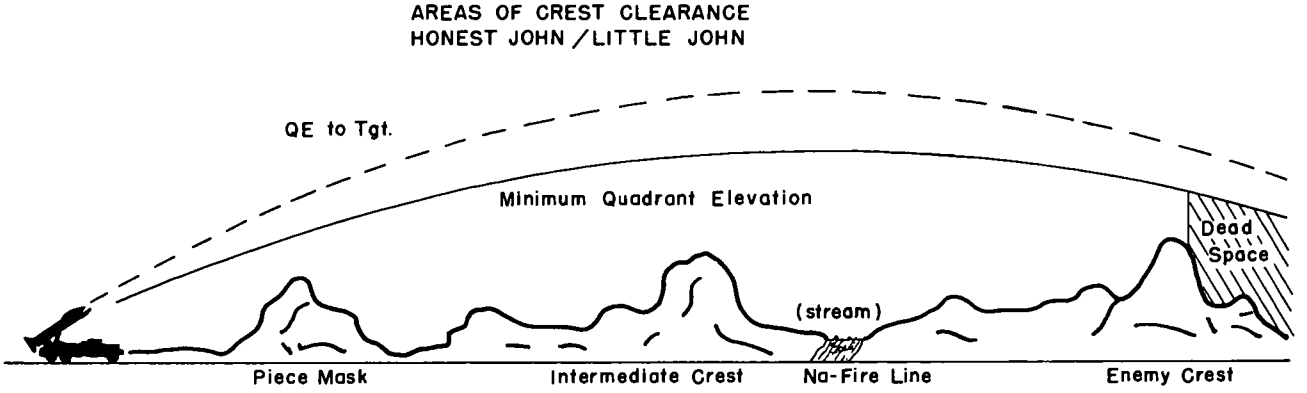


Figure 5. Areas of crest clearance.

to mils using the computational range, 6 range probable errors (PE_r) at the computational range converted to mils using the c factor, and the elevation corresponding to the computational range.

(1) When computing piece mask minimum quadrant elevation for the MGR-1A rocket, if the piece mask range is less than the minimum range contained in the Ground Data table, piece mask elevations are determined from table I, appendix II. The Ground Data tables of the MGR-1B and MGR-3A firing tables list elevations beginning with 1000 meters. PE_r and the c factor are obtained at the computational range or at the first range for which these values are listed. The following example illustrates these procedures.

(*a*) Known conditions—
Piece mask range 1600 meters
Angle of site to mask +50 mils
Rocket MGR-1A FTR 762-A-2

(*b*) Record the measured angle of site reported by the firing platoon commander: (Angle A) +50 mils

(*c*) Convert 60 meters vertical clearance at the computational range, 2000 meters (range to mask increased to the next higher thousand meters), to mils using the mil relation.
60/2 = 30 mils (Angle B) +30 mils

(*d*) Convert 6 PE_r at computational (minimum firing table) range to mils using the c factor from the Ground Data table. In this case, it is necessary to use the minimum firing table range 5000 meters.
c factor (col 3)
1.2 mils per 100 meters

PE_r (col 6) 492 meters
Therefore, 6 PE_r is converted to mils as follows:

$$6\ PE_r \times c = (6 \times 492) \times \frac{1:2}{100}$$

= 35.4 mils

Note. Express this value to the nearest mil.

(Angle C) + 35 mils

(*e*) Determine the elevation corresponding to the computational range from table I, appendix II, Elevation corresponding to range 2000
(Angle D) +85 mils

(*f*) Add angles A, B, C, and D and record the sum as the piece mask minimum quadrant elevation +200 mils

(2) If the computational range is greater than the minimum firing table range, all values are determined from the Ground Data table. The following example illustrates these procedures.

(*a*) Known conditions—
Piece mask range 5200 meters
Angle of site to mask +21 mils
Rocket MGR-3A FTR 318-A-1

(*b*) Record the measured angle of site reported by the firing platoon commander. (Angle A) +21 mils

(*c*) Convert 60 meters vertical clear-

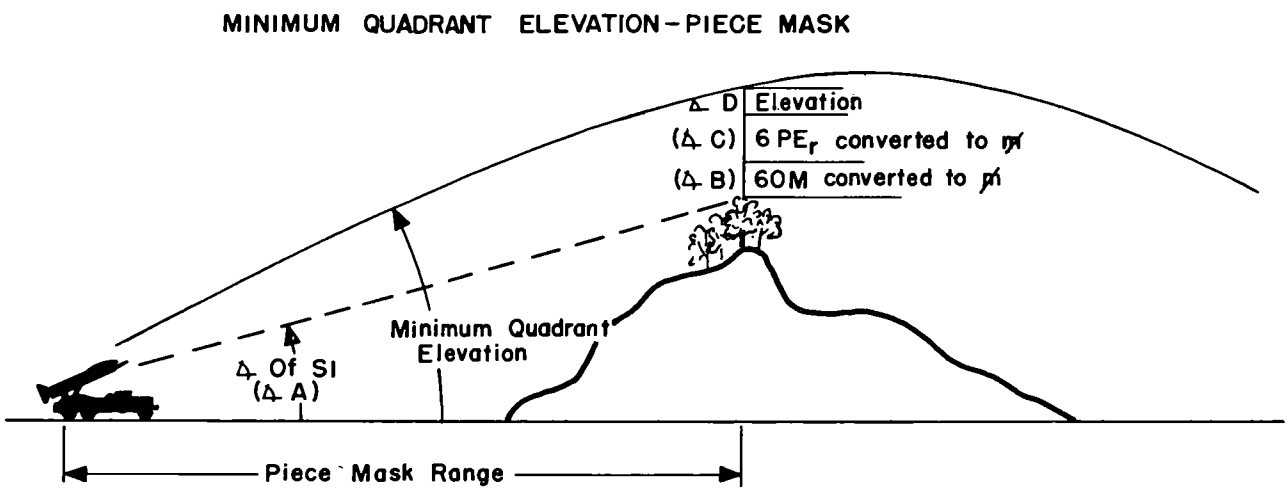


Figure 6. Piece mask minimum quadrant elevation.

ance to mils at the computational range, 6000 meters.
60/6 = 10 mils (Angle B) +10 mils

(*d*) Convert 6 PE_r at the computational range to mils using the c factor.

$$\frac{(6 \times 274) \times 1.5}{100}$$

= 24.7 mils (Angle C) +25 mils

(*e*) Determine the elevation corresponding to the computational range.
(Angle D) +113 mils

(*f*) Add angles A, B, C, and D and record the sum of the piece mask minimum quadrant elevation.
+169 mils

Note. Piece mask computations for the MGR–1B rocket are identical to those outlined above. All data is obtained from the Ground Data table of the appropriate firing table.

c. Intermediate Crest Minimum Quadrant Elevation. An intermediate crest is defined as a crest not visible from the firing position lying between the firing position and the no-fire line (fig. 7). Computation of the intermediate crest minimum quadrant elevation is the responsibility of the S3 and is based on a continuing study (usually by map) of the terrain within the unit's sector of fire. The computation is essentially the same as that used with the piece mask crest and can be considered to be composed of two parts.

(1) Compute the elevation to a point at the crest range and the height of crest with respect to the launcher plus 60 meters. Since the height of crest is known, the 60-meter vertical clearance can be added to it and the total height determined used as the height argument for entry into the firing table.

(2) Determine the value of 6 PE_r at the crest range (nearest 100 meters) and convert this value to mils using the c factor.

(3) The sum of the elevation to the point 60 meters above the crest ((1) above) plus the elevation change equivalent to 6 PE_r ((2) above) is the intermediate crest minimum quadrant elevation.

(4) The computational procedures are the same for all HONEST JOHN and LITTLE JOHN rockets. The following examples illustrate these procedures.

Example:

(*a*) Known conditions:

Crest range	6300 meters
Crest height (above launcher)	+520 meters
Rocket MGR–3A	FTR 318–A–1

(*b*) Add 60 meters to the crest height.
520 + 60 = 580 meters

(*c*) Compute the elevation corresponding to the crest range of 6300 meters and height +580 meters. Enter table C with the crest range to nearest 100 meters and height

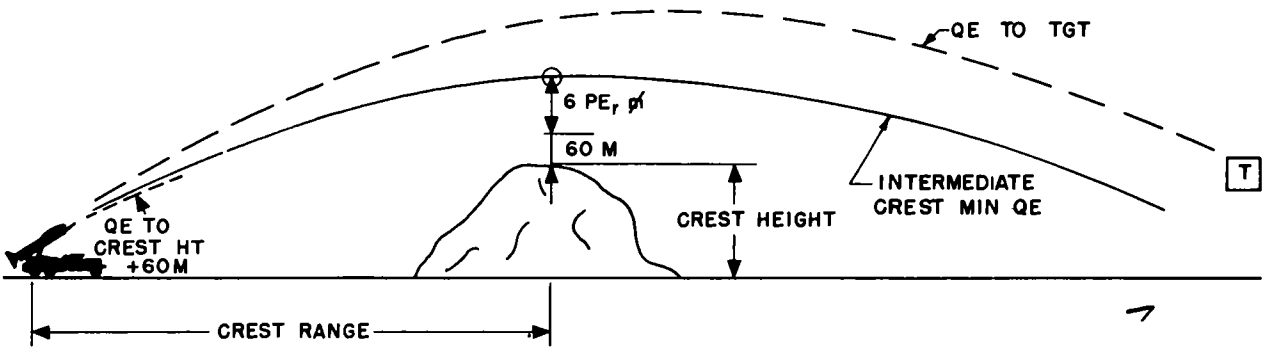


Figure 7. Intermediate crest clearance.

to the nearest 10 meters. (Interpolate.)

Range 6300	*Height*	*Elevation*
	600	211.9
	580	208.8
	500	196.3

Elevation to a point 60 meters above the crest 208.8 mils

(*d*) Convert 6 PE_r at the crest range to mils using the c factor. From the Ground Data table—
c factor (col 3) = 1.6 mils per 100 meters
PE_r (col 6) = 265 meters
Therefore, the elevation change corresponding to 6 PE_r equals—

$$\frac{(6 \times 265) \times 1.6}{100} = 25.4 \text{ mils}$$

(*e*) Add the values determined in (*c*) and (*d*) above and record the sum, to the nearest mil, as the intermediate crest minimum quadrant elevation.
208.8 + 25.4 = 234.2 234 mils

Example:

(*a*) Known conditions—
Crest range 7700 meters
Crest height (above launcher) +370 meters
Rocket MGR-1B FTR 762-H-1

(*b*) Add 60 meters to the crest height
370 + 60 = 430 meters

(*c*) Compute the elevation corresponding to the crest range of 7700 meters and height +430 meters.

Note. Since the MGR-1B firing tables present data at 200 meter range increments, it is necessary to determine the elevation to this height at range 7800 and then apply the elevation correction corresponding to a decrease of 100 meters to range 7700 meters.

Range 7800	*Height*	*Elevation*
	500	200.5
	430	191.5
	400	187.6

Elevation at range 7800 meters 191.5 mils
minus c factor (determine at height + 400) —0.3
Elevation to a point 60 meters above the crest. 191.2 mils

(*d*) Convert 6 PE_r to the crest range to mils using the c factor.
From the Ground Data table:
c factor = .9 mils per 100 meters
PE_r = 384 meters
Therefore, the elevation change corresponding to 6 PE_r equals:

$$\frac{(6 \times 384) \times .9}{100} = 20.7 \text{ mils}$$

(*e*) Add the values determined in (*c*) and (*d*) above and record the sum, to the nearest mil, as the intermediate crest minimum quadrant elevation.
191.2 + 20.7 =211.9 212 mils

d. No-fire Line Minimum Quadrant Elevation. The no-fire line is a line short of which no artillery unit may fire without prior clearance from the headquarters which established

it. Division artillery consolidates and distributes no-fire locations and information to subordinate units, to artillery reinforcing the division artillery to adjacent division artilleries, and to corps artillery headquarters. The location of the no-fire line is subject to change and the S3 must insure that the no-fire line minimum quadrant elevation data is kept current. The procedure used to determine the no-fire line minimum quadrant elevation is the same as that used for the intermediate crest except that the 60-meter vertical clearance is not required. The no-fire line minimum quadrant elevation is the sum of the elevation to the selected point along the no-fire line plus the elevation change corresponding to 6 PE_r at the no-fire line range. The following examples illustrate this procedure.

Example:

(1) Known conditions—
No-fire line range 10,000 meters
No-fire line height (above launcher) +240 meters
Rocket MGR–1B FTR 762–H–1

(2) Compute the elevation corresponding to the no-fire line range 10,000 meters and height +240 meters.
Range 10,000

Height	*Elevation*
300	188.3
240	182.2
200	178.2

Elevation to no-fire line 182.2 mils

(3) Convert 6 PE_r at the no-fire range to mils using the c factor.
From the Ground Data table—
c factor = 1.1 mil per 100 meters
PE_r = 335 meters
Therefore, the elevation change corresponding to 6 PE_r equals:

$$\frac{(6 \times 335) \times 1.1}{100} = 22.1 \quad 22.1 \text{ mils}$$

(4) Add the values determined in (2) and (3) above and record the sum, to the nearest mil, as the no-fire line minimum quadrant elevation.
182.2 + 22.1 = 204.3 204 mils

Example:

(1) Known conditions—
No-fire line range 6,200 meters
No-fire line height (above launcher) +390 meters
Rocket MGR–3A FTR 318–A–1

(2) Compute the elevation corresponding to the no-fire line range 6,200 meters and height +390 meters.
Range 6,200

Height	*Elevation*
400	180.0
390	178.4
300	164.0

Elevation to no-fire line 178.4 mils

(3) Convert 6 PE_r at the no-fire line range to mils using the c factor. From the Ground Data table—
c factor = 1.5 mils per 100 meters
PE_r = 268 meters
Therefore, the elevation change corresponding to 6 PE_r equals:

$$\frac{(6 \times 268) \times 1.5}{100} = 24.1 \quad 24.1 \text{ mils}$$

(4) Add the values determined in (2) and (3) above and record the sum, to the nearest mil, as the no-fire line minimum quadrant elevation.
178.4 + 24.1 = 202.5 202 mils

27. Limits of FDC Minimum Quadrant Elevation

If intermediate crests are isolated peaks rather than general ridge lines or the terrain at the no-fire line varies appreciably in height across the front, it will probably be unduly restrictive to use the FDC minimum quadrant elevation as determined above as governing throughout the deflection capabilities of the unit. The sector of fire should be divided into segments and the appropriate FDC minimum quadrant elevations determined within successive deflection (azimuth) limits from each individual firing position.

28. Relationship of FDC and FPC Minimum Quadrant Elevations

To facilitate the analysis of firing positions and to construct fire capabilities overlays (para. 29*c*), both the FDC and FPC minimum quadrant elevations for each position are recorded. For any selected fire mission, the larger of these two values is the final minimum quadrant elevation. However, in analyzing a position

both these values must be considered. The FPC minimum quadrant elevation is based strictly on the position-launcher-rocket combination. The FDC minimum quadrant elevation considers the direction of fire and rocket-warhead combination. It is possible for the value of the FPC minimum quadrant elevation to fall between the FDC minimum quadrant elevation for the light warhead and that for the heavy warhead for a particular direction of fire.

Example:
Minimum quadrant elevations—MGR-1B, Firing Position #3

MIN QE FPC	192 mils
MIN QE FDC (HEAVY)	200 mils
MIN QE FDC (LIGHT)	185 mils

Based on this tabulated data, the final minimum quadrant elevation for the light warhead from this position is 192 mils (MIN QE FPC) while the final minimum quadrant elevation for the heavy warhead is 200 mils (MIN QE FDC).

Also, in the case where FDC minimum quadrant elevations are computed for various segments of the unit's sector of fire each value has to be considered in each segment.

29. Dead Space

a. General. Dead space is that area beyond the no-fire line and within the maximum range of a rocket which cannot be covered by fire from firing position because of intervening crests, trajectory characteristics, or elevation limits of the lancher-rocket combination. Crests beyond the no-fire line (enemy crests) are a common cause of dead space. In addition, dead space may also occur if the FDC or firing platoon commander's minimum quadrant elevation is larger than the quadrant elevation to the no-fire line.

Note. The selection of positions from which to fire the MGR-1B rocket requires special attention to crest heights. The crest clearance and resultant dead space problems are magnified because of the comparatively low maximum ordinate and flat trajectory of the rocket. Care must be exercised to insure that intermediate crests will not place minimum range targets in dead space.

b. Crests Beyond the No-Fire Line. Prior to determining the dead space areas for a selected firing position, it is necessary to compute the minimum quadrant elevation required to clear any crest beyond the no-fire line likely to cause dead space. The computational procedures are essentially the same as those for intermediate crest clearance. Since the crest is not occupied by friendly personnel, it is not necessary to include any vertical clearance factor, and four range probable errors are considered sufficient to provide for normal dispersion and to assure crest clearance. The computation is performed in the following manner:

(1) Select the crest(s) most likely to cause dead space and obtain the crest range to the nearest 100 meters and the crest height to the nearest 10 meters.
(2) Compute the elevation corresponding to the crest range and height of crest with respect to the launcher.
(3) Determine the value of 4 PE_r at the crest range and convert this value to mils using the C factor.
(4) The sum of the elevation to the crest ((2) above) plus the elevation change corresponding to 4 PE_r ((3) above) is the elevation required to clear the crest (dead space quadrant elevation.)
(5) Compute for other selected crests.

Example:

(*a*) Known conditions:

Crest range	17,000 meters
Crest height (above launcher)	+320 meters
Rocket MGR-1B	FTR 762-H-1

(*b*) Compute the elevation corresponding to the crest range 17,000 meters and height +320 meters.

17,000 *Height*	*Elevation*
400	282.4
320	277.8
300	276.6

Elevation to the crest 277.8 mils

(*c*) Convert 4 PE_r at the crest range to mils using the C factor.

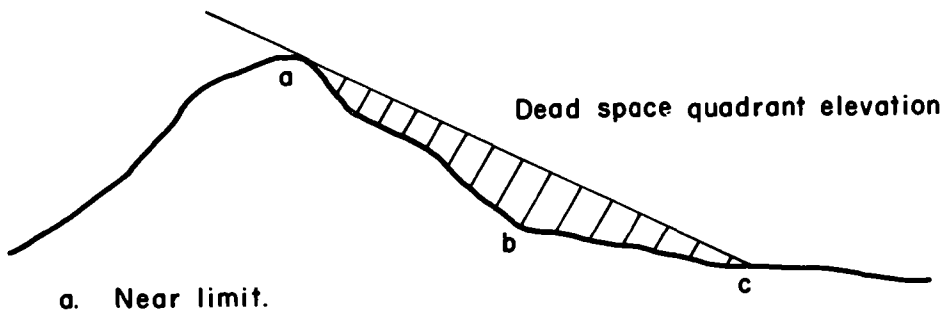
$$\frac{(4 \times 220)\ 1.9}{100} = 16.7$$

Elevation change +.6.7 mils

(*d*) Add the values determined above and record the sum, to the nearest mil, as the elevation to clear the crest (dead space quadrant elevation).

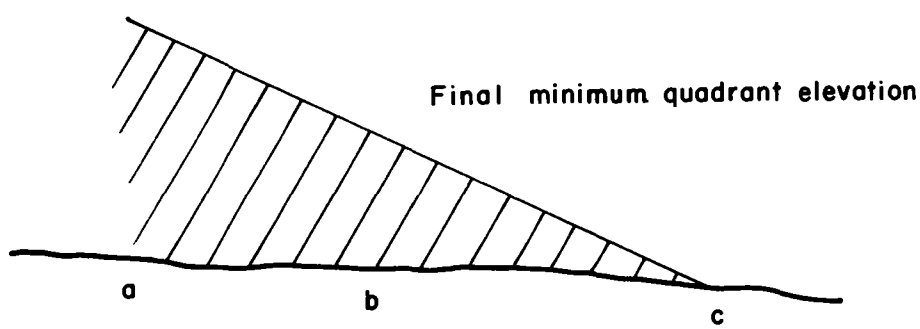
277.8 + 16.7 = 294.5 mils 294 mils

c. Dead Space Limits. To construct a fire capabilities overlay and to provide firing position data to the fire support element of the supported headquarters, the dead space areas and the minimum fire line location must be determined (fig. 8). The near limit of a dead space area is the point at which the trajectory initially intersects the ground, that is, the dead space crest. The far limit of the dead space area is the point beyond the crest at which the trajectory first intersects the ground. In the case of dead space at the no-fire line caused by the final minimum quadrant elevation, the area starts at the no-fire line and ends at the point at which the trajectory first intersects the ground. The minimum fire line range can be obtained by computing the range corresponding to the final minimum quadrant elevation at the mean relative height of the terrain beyond the no-fire line. To determine the far limit of dead space, compute the range corresponding to the dead space elevation at the mean relative height of the terrain beyond the dead space crest. These ranges, determined using the mean relative heights, may be refined through a process of successive approximation. However, they are adequate for the intent of a fire capabilities overlay. If a target plots close to the minimum



a. Near limit.
b. Dead space area.
c. Far limit.

(1) Dead space area - crest beyond the no-fire line.



a. No-fire line
b. Dead space area.
c. Minimum fire line.

(2) Dead space area- final minimum quadrant elevation

Figure 8. Dead space profiles.

fire line or a limit of dead space, the actual corrections applicable at that time must be computed to determine if the target can be attacked. The following examples illustrate the determination of the range to the minimum fire line and far limit of dead space from a selected firing position.

Example: (Minimum Fire Line)

(1) Known conditions

Final minimum quadrant elevation	232 mils
Mean relative height of terrain beyond the no-fire line	+100 meters
No-fire line range	10,000 meters
Rocket MGR-1B	FTR 762-H-1

(2) Determine the range to the nearest 100 meters corresponding to the final minimum quadrant elevation, 232 mils, and height +100 meters. By inspection, elevation 232 mils at height +100 meters falls between the listed ranges 15,000 meters and 15,200 meters.

Range	*Elevation*
15,200	234.1
15,100	232
15,000	231.0

The range to the nearest 100 meters corresponding to elevation 232 mils is range 15,100 meters.

Example: (Dead space limit)

(1) Known conditions

Dead space elevation	294 mils
Crest range	17,000 meters
Mean relative height of terrain beyond the crest	+200 meters
Rocket MGR-1B	FTR 762-H-1

(2) Determine the range to the nearest 100 meters corresponding to the dead space elevation, 294 mils, and height +200 meters. By inspection, elevation 294 miles at height +100 meters corresponds to range 18,200 meters.

Elevation	*Height*	*Range*
293.8	+200	18,200

From the two examples above, the following data are available. In this sector of fire, the no-fire line range is 10,100 meters; however, because of the final minimum quadrant elevation, the area from the no-fire line to minimum fire line at range 15,100 meters is dead space. Also because of a crest at range 17,000 meters, the area from range 17,000 meters to 18,200 meters is also dead space. If a target plots within these areas, another firing position must be selected, or the commander must be willing to accept a lesser assurance of clearing the crest in question.

30. Assurance of Crest Clearance

a. If it is indicated that a rocket cannot be fired from a position because of the crest clearance requirements (para. 26), another firing position from which the target can be attacked should be selected when time and the tactical situation permit. When the quadrant elevation (QE) to the target is less than the QE required to give the desired assurance of clearing the crest, the commander may still wish to fire on a target from that firing position. The procedure for determining the assurance or probability of clearing such a crest is as follows:

(1) Determine the crest range and height of crest with respect to the launcher (by map or computation).

(2) Determine the range at crest height corresponding to the QE to be fired.

(3) If the range corresponding to the target QE is less than the crest range, the rocket may hit the crest (less than 50 percent assurance). If the range corresponding to the target QE is greater than the crest range, subtract the crest range from the range corresponding to the target QE.

(4) Enter the Ground Data table, part 2 of the appropriate firing table, and determine the range probable error (PE_r) corresponding to the crest range.

(5) Divide the difference obtained in (3) above by the range probable error determined in (4) above. This quotient represents the clearance of the crest expressed in terms of probable error (t).

(6) Determine the assurance of clearing the crest by using the quotient obtained in (5) above as the argument, t, for entering the probability table

(Part 1 of the firing table or FM 6–40). Enter the vertical column t with the value to one decimal place (tenths) and the horizontal row t with the second decimal place (hundredths). The value obtained from the intersection of these two entries (vertical and horizontal intersection) represents one-half the area under the normal probability curve enclosed by the number of probable errors used for entry. Add 0.5000 to this value to determine the assurance of clearing the crest.

b. The following example illustrates the procedure for computing the assurance of clearing a crest:

(1) Known conditions—

Crest Range	18,100 meters
Crest Height (above launcher)	1,600 meters
Target QE	382 mils
Rocket MGR–1B	FTR 762–H–1

(2) Enter table G and determine the range at the crest height of 1600 meters corresponding to quadrant elevation 382 mils (nearest listed value). At height 1,600 meters, quadrant elevation 382 mils (381.6) corresponds to a range of 19,000 meters.

Note. To obtain an approximation of the range corresponding to the target QE, enter the Ground Data table and observe the range at the level point corresponding to the QE. Then, in the Elevation table, proceed from this range to the range at the crest height corresponding to the nearest listed value of target QE.

(3) The range corresponding to the target QE is greater than the crest range and the difference is—
19,000 —18,100 = 900 meters

(4) Enter table A, Ground Data table, with the crest range and determine the value of the range probable error (PE_r). PE_r corresponding to range 18,100 meters = 212 meters

(5) Express the range difference in terms of probable errors.

$$t = \frac{\text{range difference}}{PE_r} = \frac{900}{212} = 4.25\ PE_r$$

(6) Enter the probability table with value of t obtained above to determine one-half the area under the normal probability curve inclosed by this value.
$t = 4.25\ PE_r$ corresponds to .4980
Add 0.5000 to this value to determine the assurance of clearing the crest.
Assurance = 0.4980 + 0.5000 = .9980 = 99.80 percent

(7) The assurance may be used to determine the number of rounds that would fail to clear (would hit) the crest as follows:

(*a*) Subtract the percentage of assurance from 100 percent.
100.00 — 99.80 = 0.20 percent

(*b*) Convert the percentage difference to a decimal equivalent.

$$\frac{0.20}{100} = 0.0020$$

(*c*) Compute the number of rounds to be fired to have one round fail to clear the crest.

$$\frac{0.002}{1} = \frac{1}{X} \text{ or } X = \frac{1}{0.002} = 500$$

One round in 500 would hit the crest.

CHAPTER 5
FIRING SECTION

31. General

Duties of individual launcher crewman for the HONEST JOHN System are described in FM 6–9 (M386 and M33 launchers) and FM 6–60 (M289 launcher). The duties of the individual crewman for the LITTLE JOHN System are described in FM 6–57 (M34 launcher). The procedure and techniques presented in this chapter are directly related to the 762-mm rocket (HJ) and the 318-mm (LJ) rocket and must be accorded particular emphasis in the unit training program.

32. Areas Requiring Special Attention

a. An orienting angle will be the primary means of laying the launcher for direction. The unit survey section will carry survey control to each firing position and establish an orienting line for each position. The launcher can be laid by azimuth, however, this procedure is not recommended for normal use since the possibility of an orientation error is extremely high.

b. Other areas that require special attention are—

(1) *Boresighting.* On carriage sighting and aiming, equipment must be checked prior to each firing. These checks are conducted as prescribed in the appropriate field manuals.

(2) *Temperature conditioning of rockets.* A temperature conditioned rocket is one in which the propellant temperature is uniform throughout the grains. This condition is essential to insure even burning of the propellant. If the rocket motor is improperly conditioned, the temperature gradient (differences in temperature throughout the propellant grain) will cause uneven burning and contribute to the thrust malalinement error (a so-called noncorrectable). Further, a temperature gradient makes it impossible to obtain a valid propellant temperature measurement for use in computing temperature corrections. Blankets are provided for temperature conditioning purposes, and proper use of this equipment is essential. The following procedure will produce the best results:

(*a*) The rocket should not (unless absolutely necessary) be exposed to the direct rays of the sun or to a cold chilling wind. Exposure to such environments for even a short period of time will result in an improperly conditioned rocket.

(*b*) Blankets should be installed when rocket motors are drawn from the SASP.

(*c*) Blankets should remain on the rocket until at least 15 minutes prior to firing (longer if possible).

(*d*) Blankets should be used primarily as insulation devices (no heat applied) unless the ambient temperature is below minimum permissible storage limits. Heat is then applied to maintain the rocket motor within the storage limits. The blankets for the LITTLE JOHN rocket provide insulation only and do not have a heating capability. The rocket conditioning kit is used to heat the LITTLE JOHN rocket.

(*e*) If the ambient temperature is expected to go below minimum firing limits, the motor should be heated continuously for a minimum of 24 hours prior to firing. Heating for 48 hours is recommended.

Note. ALWAYS INSULATE. HEAT ONLY WHEN NECESSARY.

(3) *Seating of propellant.* The launcher should be elevated to at least 800 mils to properly seat the propellant

grains in the MGR-1A rocket prior to firing.

33. Low-Level Winds

The measurement of low-level winds and the correlation of the wind effects to cause the rocket to respond favorably is a difficult problem. Low-level winds affect the rocket during the entire burning phase with the effects being greatest just as the rocket leaves the launcher and diminishing rapidly to motor burnout. Low-level winds are measured by exposing the anemometer of a wind measuring set at 50 feet. This measurement is weighed to provide an estimate of the wind that the rocket actually "sees" (senses) during the burning phase. This method produces valid results (within accepted tolerances) if the procedures outlined in paragraphs 35 and 36 are followed.

34. Low-Level Wind Corrections

Corrections for low-level winds may be determined in the fire direction center, however, these corrections are normally determined in the firing section. The primary and recommended method of measuring the velocity and direction of the low-level wind is to use the table of organization and equipment wind measuring set. If the wind measuring set is not available, low-level winds may be measured using a 30-gram pilot balloon and a theodolite (para. 37), or, as a last resort, they may be obtained from line 0 of the metro message. The wind measuring sets used with the HONEST JOHN system are the AN/PMQ-6, AN/MMQ-1A, and AN/MMQ-1B. The wind measuring set used with the LITTLE JOHN system is the AN/PMQ-6.

35. Use of Wind Measuring Sets

a. Placement of Wind Measuring Set. The wind measuring set should be emplaced 50 meters in front of the launcher and, for safety and the protection of equipment, at least 25 meters to the side of the trajectory. These distances may be paced by a launcher crewman since they are not critical. The most important consideration is to locate the wind measuring so that the wind pattern at the set is similar to the wind pattern at the launcher.

b. Orientation of Wind Measuring Set Mast. The wind measuring set mast should be oriented initially parallel to the azimuth of fire. If the deflection corrections for nonstandard conditions exceed 25 mils, the mast should be reoriented to the corrected firing azimuth before corrections for low level winds are determined. Care must be exercised to insure the wind is not misoriented 3,200 mils.

c. Profile corrections. Wind velocity usually increases with height, and the wind structure (wind profile) varies with the time of day. It is impossible for an anemometer exposed at 50 feet in the air to correct for such variations. Therefore, the low-level wind measurements obtained in the firing section must be weighted to account for these differences. Wind profile correction factors are normally incorporated into the low-level wind correction tables found in the tabular firing tables. This results in two such tables—one for NIGHTTIME conditions and the other for ALL OTHER THAN NIGHTTIME conditions. A third table is included for the PILOT BALLOON OR MET LINE O technique and has no profile correction factor incorporated. NIGHTTIME is defined as the period extending from 1 hour before sunset to 1 hour after sunrise, with clear skies (or few clouds) and wind speeds less than 10 miles per hour. If *all* NIGHTTIME conditions do not exist simultaneously, the tables for ALL OTHER THAN NIGHTTIME conditions must be used. The appropriate table is entered with the quadrant elevation (corrected) to the nearest mil, to obtain low-level wind factors that include profile corrections. The low-level wind readings are multiplied by these factors to obtain low-level wind corrections.

36. Techniques for Measuring and Applying Low-Level Wind Corrections

If the wind measuring set is used, either the recurring wind technique or the predicted wind technique for measuring and applying low-level wind corrections may be used. The tactical considerations will normally require that the predicted technique be used.

a. Recurring Wind Technique. Corrections for low-level wind are determined and the rocket is fired when the same wind conditions recur within a tolerance of plus or minus 1 mile per hour in both range wind and cross wind components for which corrections have been computed. The procedure is as follows:

(1) Set the MINUTE switch on the panel

of the windset indicator to the one (1) minute position.

(2) Place the AVERAGE/DIRECT reading control switch in the AVERAGE position.

(3) Take six readings from the wind measuring set at 1 minute intervals, beginning 7 minutes prior to firing (X–7). Readings obtained are in miles per hour (cross wind and range wind.) Add these readings algebraically and compute the AVERAGE components:

Example:

Time	*Cross wind (mph)*	*Range wind (mph)*
X–7	L5	H5
X–6	L6	H4
X–5	L3	H5
X–4	L6	H6
X–3	L4	H3
X–2	L5	H5
Total	L29	H28
Average	L5	H5

(4) Enter the firing tables (in this case FTR 762–G–1 is used, table M–1, part 2) and determine the appropriate unit correction factor for a 1 mile per hour low level range (head or tail) wind and low level (cross) wind. Argument for entry is the quadrant elevation (corrected) to the nearest mil from the fire command.

Example: For firing under OTHER THAN NIGHTTIME CONDITIONS with a quadrant elevation (corrected) of 666.2 mils, enter table M–1.

	Unit correction factor	
Quadrant elevation	*Lateral (cross wind)*	*Head wind*
666	3.55	+1.75

(5) Multiply these unit correction factors by the averages computed from the wind measuring set readings in (4) above.

Example:

Lateral wind:

3.55 × L5 = L18 mils (L17.75)

Range wind:

+1.75 × 5 = + 8.8 mils (+8.75)

(6) Apply the corrections computed in (5) above to the launcher.

(7) Fire the rocket when the readings on the wind measuring set are within the tolerance of the average readings initially computed in (3) above. The rocket would be fired when the wind measuring set readings are—

L5 ± 1 MPH

H5 ± 1 MPH

b. Predicted Wind Technique. The predicted wind technique is based on averaging of the winds for 5 minutes, applying the corrections to the launcher, and firing at the time equal to time on target (TOT) minus time of flight (TF). The procedure is as follows:

(1) At 7 minutes prior to firing (X–7), set the MINUTE switch on the data indicator of the wind measuring set to 5 minutes.

(2) Place the AVERAGE/DIRECT reading control switch in the AVERAGE position.

(3) At 2 minutes prior to firing (X–2), record the wind measuring set readings.

Example:

	Readings	
Time	*Cross Wind (mph)*	*Range Wind (mph)*
X–2	R6	H3

(4) Enter the firing table and determine the appropriate unit correction factors for a 1-mile per hour low-level range (head or tail) wind, and low-level cross (lateral) wind. Argument for entry in the quadrant elevation (corrected) to the nearest mil from the fire command.

Example: For firing under OTHER THAN NIGHTTIME CONDITIONS with a quadrant elevation (corrected) of 457.8 mils, enter table M–1, FTR 762–G–1.

		Unit correction factor	
Quadrant	*Elevation*	*Lateral (cross wind)*	*Head wind*
458		2.98	+1.12

(5) Multiply the unit correction factors by the wind measuring set readings in (3) above.

Example:

Lateral wind:

2.98 × R6 = R18 (R17.88)

Range wind:

+1.12 × 3 = 3.4 (+3.36)

(6) Apply the corrections computed in (5) above to the launcher.
(7) At X–0, fire the rocket.

c. Criteria for Selecting Recurring Wind or Predicted Wind Techniques. The commander should consider the following factors in selecting the low level wind correction technique for a particular mission:

(1) *Accuracy.* Both the recurring wind and predicted wind techniques are acceptable. However, the recurring wind technique generally will produce more accurate results.

(2) *Timeliness of fire.* With the predicted wind technique, the rocket can be fired at a designated time. With the recurring wind technique, the exact time of firing cannot be predicted. The probability of the wind recurring within the prescribed tolerance of ± 1 mile per hour in each component is as follows:

(*a*) If the last wind measuring set reading is recorded 2 minutes prior to the time of firing (X–2), allowing 2 minutes for the launcher crew to compute and apply launcher corrections, the correct wind will recur—

40 percent of the time at X–0
20 percent of the time between X–0 and X+3 minutes
15 percent of the time between X+3 and X+8 minutes
5 percent of the time between X+8 and X+18 minutes
20 percent of the time, *never.*

(*b*) If the last wind measuring set reading is recorded 4 minutes prior to the time of firing (X–4), allowing 4 minutes for launcher crew to compute and apply corrections, the correct wind, will recur—

35 percent of the time at X—0
20 percent of the time between X—0 and X+3 minutes
15 per cent of the time between X+3 and X+8 minutes
5 percent of the time between X+8 and X+18 minutes
25 percent of the time, *never.*

(*c*) Note that because of the fluctuations, direction, and speed of low level winds, a wind that does not recur within a few minutes is not likely to recur at all. The less time it takes the launcher crew to measure and apply corrections, the better are the chances of obtaining a recurring wind.

(3) *Complexity of operations.* The recurring wind technique is more complex only in that it requires the average of six wind measuring set readings, whereas, the predicted wind technique requires only one recorded wind measuring set reading.

37. Single Theodolite Pilot Balloon Method

If the windset is not available or is not in a serviceable condition, low-level winds may be measured by using a standard theodolite (ML–247 with tripod ML–79 or ML–474–GM with tripod ML–79 or MT 1309/GM) and a 30-gram pilot balloon. In the single theodolite method, a standard rate of rise is assumed for the 30-gram balloon. This assumption is subject to gross error. Consequently, this technique is recommended as a secondary means or backup for the windset. The corrections obtained in this manner will not ordinarily be as reliable as windset correction weighted for profile conditions. The procedure for determining corrections by this method is outlined below. Figure 9 is an example of the computation required.

a. Location of Theodolite. The theodolite should be located near the launcher, approximately 50 meters upwind.

b. Orientation of Theodolite. The theodolite must be oriented in the direction of fire. That is, the azimuth reading must be zero when the operator's line of sight through the right angle telescope is in the direction of fire. This can be accomplished by using any one of the methods listed below.

(1) *Orienting angle method.* The orienting angle method is recommended as the primary method for orienting the theodolite since it produces the most accurate solution with minimum effort by the launcher crew. A theodolite

LOW LEVEL WIND CORRECTIONS, SINGLE THEODOLITE PILOT BALLOON TECHNIQUE

1. Weather conditions:
   A. Nightime _____
   B. All other than nightime X
2. Theodolite orienting data:
   A. Azimuth orienting line 196.1 degrees
   B. Azimuth of fire 260.3 degrees
   C. Orienting angle 296.8 degrees
3. Time of flight for balloon 32 seconds
4. Vertical angle to balloon 48.7 degrees
5. Azimuth reading to balloon 241 degrees
6. Total corrections low level winds:
   A. Cross wind correction:
      Deflection: 7.3 (wd speed) mph X R (L) 0.87 (wd comp) = R (L) 6.4 (cross wd) mph X 4.60 (unit corr DF) = R (L) 29 mil
   B. Range wind correction:
      Quadrant elevation: 7.3 (wd speed) mph X (H) T 0.48 (wd comp) = (H) T 3.5 (range wd) mph X +1.52 (unit corr QE) = (+) 5.3 mil
7. Final firing data:
   A. Deflection (corrected) 2814 mil
      Low level wd corr DF: R (L) 29 mil
      FINAL DEFLECTION 2843 mil
   B. QE (corrected) 403.8 mil
      Low level wd corr QE (+) 5.3 mil
      FINAL QE 409.1 mil

4 _____ degrees
5 _____ degrees
6A _____ mph X R L _____ = R L _____ mph
6B _____ mph X R L _____ = R L _____ mph

Use this box for data of firing time.

Figure 9. Low level wind corrections, single theodolite and pilot balloon technique.

stake (location) and orienting line (line of known direction) must be established in the firing position by the unit survey section. The orienting angle, which is based on the azimuth of fire, is computed by the fire direction center in a manner similar to the computing of the orienting angle for the launcher. The exceptions are that the theodolite orienting angle must be expressed in degrees (to nearest tenth of a degree). The procedure for the theodolite crew is as follows:

(*a*) Set up and level the theodolite (TM 11-6675-200-10) over the theodolite stake.

(*b*) Obtain the orienting angle from the launcher section commander.

(*c*) Disengage the azimuth and tracking control and set the orienting angle on the azimuth scale.

(*d*) Engage the azimuth tracking control and loosen the azimuth calibration clamp.

(*e*) Approximately orient the theodolite by sighting on the far end of the orienting line (through the telescope) using the fast motion.

(*f*) Tighten the azimuth calibration clamp and precisely orient the theodolite by using the azimuth calibration adjustment.

(2) *Aiming circle method.* After the aiming circle has been oriented in the direction of fire, the following procedures should be used:

(*a*) Set up and level the theodolite.

(*b*) Sight on the telescope of the theodolite with the aiming circle and determine the instrument reading (not the deflection).

(c) Convert this reading to degrees (nearest tenth of a degree) and relay the information to the theodolite operator.

(*d*) Disengage the azimuth tracking control and set the reading obtained from the aiming circle on the azimuth scale of the theodolite. Engage the azimuth tracking control.

(*e*) Loosen the azimuth calibration clamp on the theodolite.

(*f*) Plunge the theodolite telescope.

(*g*) Sight the theodolite on the aiming circle using fast motion.

(*h*) Tighten the azimuth calibration clamp on the theodolite and sight exactly on the aiming circle using the azimuth calibration adjustment.

(*i*) Plunge telescope back to zero degrees elevation. The theodolite is now oriented.

(3) *Compass method.* The procedure for using the compass method is as follows:

(*a*) Obtain the direction of fire (in degrees to nearest tenth) from the launcher platoon commander.

(*b*) Subtract the direction of fire from 360° plus or minus the correction for magnetic declination. This value (declination correction) is read from a map. For an east declination, the correction is added to 360°; and for a west declination, the correction is subtracted from 360°.

(*c*) Disengage the azimuth tracking control and set the difference (obtained in (*b*) above) on the azimuth scale of the theodolite.

(*d*) Engage the azimuth tracking control and loosen the azimuth calibration clamp.

(*e*) Lower the lifter lever on the compass and allow the magnetic needle to rotate freely on its axis.

(*f*) Orient the theodolite using the magnetic compass (TM 11–6675–200–10).

(*g*) Tighten the azimuth calibration clamp. The theodolite is now oriented.

c. Inflation Procedures. Inflate the 30-gram balloon using the procedures prescribed in FM 6–15 and TM 11–2405. The balloon must be inflated while in an inclosed shelter to protect it from the wind. Errors in the rate of rise will result from improper inflation. A ¾-ton or 2½-ton truck with canvas installed may be used as a shelter.

d. Determination of Low-level Wind Components. The wind measurement is accomplished by a single observation of the pilot balloon at a time following its release which is dependent on the quadrant elevation (corrected), the type rocket, and the existing wind profile. Both a vertical and horizontal reading is obtained at the time of observation. The measured vertical angle is used to determine the wind speed. The measured horizontal angle is the basis for determining correction components used to resolve the indicated wind into range and cross wind components. The following example illustrates the procedures used to determine low-level wind components in the pilot balloon technique.

(1) Statement of known conditions.

(*a*) Rocket MGR–1A (FTR 762–F–1).

(*b*) Quadrant elevation (corrected) 403.8 mils.

(*c*) Existing wind profile ALL OTHER THAN NIGHTTIME.

(2) Determine the time to read the vertical and horizontal angles to the balloon from table II, appendix II. Enter the table for the MGR–1A rocket with the quadrant elevation to the nearest listed value and the existing wind profile.

Note. If the quadrant elevation is less than the minimum value listed, use the minimum time listed.

ALL OTHER THAN NIGHTTIME CONDITIONS

QE Mils	*Time in Seconds*
400	32

(3) Read and record the verticle and horizontal angles to the pilot balloon 32 seconds after release. Determine the vertical angle to the nearest tenth of a degree and the horizontal angle to the nearest degree.

Vertical angle 48.7°
Horizontal angle 241°

(4) Enter table III, appendix II, with the measured vertical angle and determine the corresponding wind speed in miles per hour.

Degrees	0.7
	Windspeed (miles per hour)
48	7.3

(5) Enter table IV, appendix II, with the measured horizontal angle and determine the wind correction components.

WIND CORRECTION COMPONENTS

Degrees	*Range wind*	*Cross wind*	*Degrees*
------	H .48	.87 L	241

(6) Multiply the indicated wind speed by the correction components to determine the cross wind and range wind components in miles per hour.

Cross wind =
7.3 × LO.87 = L6.4 MPH
Range wind =
7.3 × HO.48 = H3.5 MPH

e. Determination of Low-Level Wind Corrections. It is not necessary to apply wind profile corrections when using the pilot balloon technique. The profile condition considered in determining the observation time is ignored and unit corrections for a one mile hour range or cross wind are determined from the PILOT BALLOON OR MET LINE 0 correction table. The total correction to deflection or elevation to compensate for the low-level wind effects is the product of the wind component (*d* above) and the unit correction from the firing table. Continuing the example from *d* above, the procedure is as follows:

(1) Enter Table E 3 (FTR 762–F–1) with the corrected quadrant elevation 404 (nearest mil) and determine the unit correction factor for a one mile per hour low-level cross wind and head wind:

Unit Correction Factor

Quadrant Elevation	*Cross wind*	*Head wind*
404	4.60	+1.52

Note. The direction of the cross wind correction is determined from the letter preceding the cross wind component. The direction of the range wind correction is indicated by the sign of the unit correction.

(2) Multiply the unit correction factors by the appropriate wind component from *d*(6) above:

Cross wind (DF):
4.60 × L 6.4 = L29 mils
Range wind (QE):
+1.52 × H 3.5 = +5.3 mils

(3) Apply the corrections computed in (2) above to the corrected deflection and quadrant elevation. A correction to time of flight for the effects of low-level winds is not computed.

38. Firing Section Recorder Sheet

Figure 10 (DA Form 2257–R, Rocket Launcher Section Recorder Sheet) is a form which may be used to record data pertinent to the firing section. DA Form 2257–R will be reproduced locally on 8 inch X 13 inch paper.

ROCKET LAUNCHER SECTION RECORDER SHEET
(FM 6-40-1)

UNIT 3d Msl Bn, 82d Army | DATE 3 Apr 64 | TIME FIRED 0725

WARNING ORDER		PLATOON COMMANDER'S REPORT	
Launcher to Fire	2	Launcher	2
Firing Position	1	Firing Position	1
Type Rocket	MGR-1A	Measured Azimuth of Fire	4626 mils
Type Warhead	M-38	Measured Orienting Angle	2060 mils
Fuse Option *	Air / Impact	Aiming Post Deflection	2800 mils
Height of Burst Option *	High / Low	Firing Limits (If Nec)	R2533 L3065
Method of Fire	(1) AMC	Launcher-Rocket ME	178 mils
Predicted Time of Fire	0725	Angle of Site to Mask	+ 60 mils
INITIAL LAYING DATA		Range to Mask	1600 mils
Az of DL	286 mils	Rocket Type and Motor Serial No.	MGR-1A #2135
Az of Fire	4626 mils	Warhead	M 38
Orienting Angle	2060 mils	Propellant Temperature	65 °F
Quadrant Elevation	672 mils	Prop Wt Corr(MGR-1B AND MGR-3A) Propellant Wt(MGR-1A)	2049 lb
FDC MIN QE 194 mils		Surface Pressure (If Nec)	998 mb
		Empty Weight	3843 lb

WEIGHT COMPUTATIONS

MGR-1B OR MGR-3A ROCKET			MGR-1A ROCKET (MOTOR EMPTY WEIGHT NOT GIVEN)		
Motor Empty Weight		lb	1 Propellant Weight		lb
Warhead Section Weight	+	lb	Spin Rocket 2 Propellant Weight	+	lb
Empty Weight	=	lb	Sum of 1 and 2	=	lb
Propellant Wt Corr	+ −	lb	Gross Motor Weight		lb
MGR-1A ROCKET (MOTOR EMPTY WEIGHT GIVEN)			Warhead Section Weight	+	lb
Motor Empty Weight	2019	lb	Fin Weight	+	lb
Warhead Section Weight	+ 1650	lb	Launch Shoe Adopters Weight (If Nec)	+	lb
Fin Weight	+ 166	lb	Gross Rocket Weight	=	lb
Launching Shoe Adopters Weight (If Nec)	+ 8	lb	Sum of 1 and 2 From above	−	lb
Empty Weight	= 3843	lb	Empty Weight	=	lb
Propellant Weight	2049	lb	Propellant Weight (1 above)		lb

LDW LEVEL WIND DATA:		Df	QE	FINAL FIRING DATA			
WINDSET	Unit Corr Factors	9.22	± 4.83	Corr. Data From FDC	Df 2795	Ti 64.1	QE 666.2
	Reading at X-	R 2	T 5	Low Level Wind Corr.	R 18		± 24.2
	L.L. Wind Correction	R 18	± 24.2	Fuse Corr (XM4( ), M6)		+ −	
PILOT BALLOON	L.L. Wind Correction	= L R	= + −	Data Fired	Df 2813	Ti 64.1	QE 6904

*See FM 6-40-1A (Honest John/Little John)

DA FORM 2257-R, 1 Aug 64 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

Figure 10. Rocket launcher section recorder sheet.

APPENDIX I

REFERENCES

1. Publication Indexes

Department of the Army Pamphlets of the 310-series should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to material covered in this manual.

2. Army Regulations

AR 320–5	Dictionary of United States Army Terms.
AR 320–50	Authorized Abbreviations and Brevity Codes.
AR 385–63	Regulations for Firing Ammunition for Training, Target Practice, and Combat.
AR 525–30	Army Missiles.

3. Army Training Tests

ATT 6–175	Field Artillery Missile Battalion and Battery, HONEST JOHN and LITTLE JOHN.

4. Army Training Programs

ATP 6–302	Army Training Program for Field Artillery Missile Units, HONEST JOHN and LITTLE JOHN Rocket.

5. Department of the Army Pamphlets

DA Pam 108–1	Index of Army Motion Pictures, Filmstrips, Slides, and Phono-Recordings.
DA Pam 310-series	Military Publications Indexes.

6. Field Manuals

FM 6–2	Artillery Survey.
FM 6–20–1	Artillery Tactics.
FM 6–20–2	Artillery Techniques.
FM 6–40	Field Artillery Cannon Gunnery.
(S) FM 6–40–1A	Field Artillery HONEST JOHN/LITTLE JOHN Rocket Gunnery (U).
FM 6–56	Field Artillery Missile Battalion (Battery) LITTLE JOHN Rocket.
FM 6–57	Field Artillery Rocket, LITTLE JOHN with Launcher M34.
FM 6–59	Field Artillery Rocket HONEST JOHN with Launchers M386 and M33.
FM 6–60	Field Artillery Rocket HONEST JOHN with Launcher M289.
FM 6–61	Field Artillery Missile Battalion; HONEST JOHN Rocket, Self-Propelled.
FM 6–140	The Field Artillery Battery.
FM 21–5	Military Training.
FM 21–6	Techniques of Military Instruction.
FM 21–26	Map Reading.
FM 21–30	Military Symbols.
FM 32–5	Communication Security (U).
FM 101–31–1	Nuclear Weapons Employment (U).

(S) FM 101–31–2	Nuclear Weapons Employment (U).
FM 101–31–3	Nuclear Weapons Employment (U).

7. Firing Tables

FTR 318–A–1	Firing Tables for Launcher: Rocket 318-mm M34 Rocket, 318-mm XM51 with Warhead Section XM50. Warhead Section XM78, Warhead 318-mm Rocket, HE T54E1, Warhead Section, 318-mm Rocket Flash Smoke XM8.
FTR 318–ADD–A–1	Firing Table Addendum to FTR 318–A–1 for Warhead T54E1.
FTR 762–A–2	Firing Tables for Launcher, Rocket: 762-mm, Truck Mounted M289, Firing Rocket, 762-mm; M31A1 and M31A1C with Warhead HE, 762-mm Rocket, M6; Warhead, 762-mm Rocket, Flash-Smoke XM4E1, FSXM38, M144.
FTR 762–B–2	Firing Tables for Launcher, Rocket: 762-mm, Truck Mounted, M289, Firing Rocket, 762-mm: M31A1 and M31A1C with AKXM86, XM27, XM47, XM48 and E19R2.
FTR 762–C–1	Firing Tables for Launcher, Rocket 762-mm, XM33 Firing Rocket 762-mm: M31 Mods with AKXM86, XM27, XM47, XM48, and E19R2.
FTR 762–D–1	Firing Tables for Launcher, Rocket 762-mm, XM33 Firing Rocket 762-mm: M31 Mods with Warhead HE 762 mm Rocket M6, Warhead HE 762 mm Rocket T2044E1, Warhead 762 mm Rocket FS X M38 Warhead, Fragmentation T39E Mods.
FTR 762–E–1	Firing Tables for Launcher Rocket 762 mm, Truck Mounted, M386; Firing Rocket, 762-mm: M31 Mods with AKXM86, XM27, XM47, XM48, E19R2.
FTR 762–F–1	Firing Tables for Launcher, Rocket: 762-mm Truck Mounted, M386, Firing Rocket. 762-mm: M31 Mods with Warhead, HE, 762-mm Rocket, M6; Warhead, 762-mm Rocket, FSXM4E Mods; FSXM38 Mods, M144 (T 2044E 1) HE M57(T39E1), M79 (E19R1).
FTR–762–ADD–A–1	Firing Table Addendum for Launchers M289, M33, M386. Firing Rocket 762-mm M31 Mods with M144 (T 2044E1).
FTR 762–ADD–B–1	Firing Table Addendum for Launchers M289, M33, M386 Firing Rocket 762-mm M31 Mods with Warhead M6.
FTR 762–G–1	Firing Tables for Launcher, Rocket: 762-mm Truck Mounted, M386 Firing Rocket, 762-mm: M50 Mods with Warhead Sections M27, M47, M48, E19R2.
FTR 762–H–1	Firing Tables for Launcher Rocket: 762-mm Truck Mounted, M386 Firing Rocket, 762-mm: M50 Mods with Warhead Section, HE: M144 (T2044E1) Warhead Section, Practice M38.
FTR 762–I–1	Firing Tables for Launcher Rocket: 762-mm M33 Firing Rocket, 762-mm: M50 Mods with Warhead Sections M27, M47, M48, E19R2.
FTR 762–J–1	Firing Tables for Launcher Rocket: 762-mm M33 Firing Rocket, 762-mm M33 Firing Rocket, 762-mm M50 Mods with Warhead Section HE: M144 (T2044E1), Warhead Section, Practice, M38.
FTR 762–K–1	Firing Tables for Launcher, Rocket: 762-mm Truck Mounted, M289 Firing Rocket, 762-mm: M50 Mods with Warhead Sections M27, M47, M48, E19R2.
FTR 762–L–1	Firing Tables for Launcher, Rocket: 762-mm Truck Mounted, M289 Firing Rocket, 762-mm M50 Mods with Warhead Section, HE: M144 (T2044E1). Warhead Section, Practice M38.

FTR 762-ADD-C-1	Firing Table Addendum to FTR 762-H-1, FTR 762-J-1, FTR 762-L-1 for Warhead, M144 (T2044E1).

8. Technical Manuals

TM 6-230	Logarithmic and Mathematical Tables.
TM 9-1340-202-12	Operator and Organizational Maintenance Manual, 762-mm Rockets M31 series and XM50.
TM 9-1950	Rockets.
TM 11-6660-203-10	Operators Manual: Wind Measuring Sets AN/MMQ-1A, AN/MMQ-1B, and AN/PMQ-6.
TM 11-6675-200-10	Operators Manual: Theodolites ML-47-C through ML-47-R, ML-247, and ML-247A.

APPENDIX II

TABLES

Table I. Quadrant Elevation for Mask Ranges to 5,000 meters

Mask range (meters)	Quadrant elevation (mils)	
	M289 launcher FTR 762-A-2	M289 launcher FTR 762-B-2
1000	48	42
2000	85	78
3000	117	107
4000	143	130
5000	165	148
	M386 launcher FTR 762-E-1	M386 launcher FTR 762-F-1
1000	54	61
2000	102	111
3000	137	147
4000	161	172
5000	177	189
	M33 launcher FTR 762-C-1	M33 launcher FTR 762-D-1
1000	54	61
2000	102	111
3000	137	147
4000	161	172
5000	177	189

Table II. Time to Read Vertical and Horizontal Angles When Using Pilot Balloon Techniques to Measure Low Level Winds

MGR-1A and MGR-1B

All other than nighttime conditions		Nighttime conditions	
QE mils	Time in seconds	QE mils	Time in seconds
200	20	200	24
240	22	220	26
280	25	240	27
320	27	260	29
360	30	280	30
400	32	300	31
450	35	320	33
500	37	340	34
550	40	360	35
600	42	380	36
650	44	400	37
700	46	440	39
800	49	480	41
900	52	520	43
		560	45
		600	46
		650	48
		700	50
		750	51
		800	52
		850	54
		900	55

MGR-3A

All other than nighttime conditions		Nighttime conditions	
QE mils	Time in seconds	QE mils	Time in seconds
200	20	200	20
240	20	240	20
280	20	280	21
320	20	320	24
360	22	360	27
400	25	400	29
450	27	450	32
500	30	500	35
550	32	550	37
600	34	600	39
650	36	650	41
700	38	700	43
800	41	800	47
900	43	900	49

Note. Nighttime is defined as the period from 1 hour *before* sunset to 1 hour *after* sunrise, with clear skies (few clouds) and light winds (under 10 mph).

Table III. Wind Speed Table for Low Level Winds: Pilot Balloon Technique
(Argument for entry is vertical angle to nearest tenth degree.)

Degrees	Elevation Angle of Balloon in Degrees and Tenths of a Degree									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Table									
	Wind speed (miles per hour)									
5	94.4	92.5	90.8	89.0	87.4	85.8	84.3	82.8	81.3	79.9
6	78.6	77.3	76.0	74.8	73.7	72.5	71.4	70.3	69.3	68.3
7	67.3	66.3	65.4	64.5	63.6	62.7	61.9	61.1	60.3	59.5
8	58.8	58.0	57.3	56.6	55.9	55.3	54.6	54.0	53.4	52.8
9	52.2	51.6	51.0	50.4	49.9	49.4	48.8	48.3	47.8	47.3
10	46.8	46.4	45.9	45.5	45.0	44.6	44.1	43.7	43.3	42.9
11	42.5	42.1	41.7	41.3	41.0	40.6	40.2	39.9	39.5	39.2
12	38.9	38.5	38.2	37.9	37.6	37.3	37.0	36.7	36.4	36.1
13	35.8	35.5	35.2	34.9	34.7	34.4	34.1	33.9	33.6	33.4
14	33.1	32.9	32.6	32.4	32.2	31.9	31.7	31.5	31.3	31.0
15	30.8	30.6	30.4	30.2	30.0	29.8	29.6	29.4	29.2	29.0
16	28.8	28.6	28.4	28.3	28.1	27.9	27.7	27.5	27.4	27.2
17	27.0	26.9	26.7	26.5	26.4	26.2	26.0	25.9	25.7	25.6
18	25.4	25.3	25.1	24.0	24.8	24.7	24.5	24.4	24.3	24.1
19	24.0	23.9	23.7	23.6	23.5	23.3	23.2	23.1	22.9	22.8
20	22.7	22.6	22.5	22.3	22.2	22.1	21.0	21.9	21.7	21.6
21	21.5	21.4	21.3	21.2	21.1	21.0	20.9	20.8	20.7	20.6
22	20.4	20.3	20.2	20.1	20.0	19.9	19.8	19.8	19.7	19.6
23	19.5	19.4	19.3	19.2	19.1	19.0	18.9	18.8	18.7	18.6
24	18.6	18.5	18.4	18.3	18.2	18.1	18.0	18.0	17.9	17.7
25	17.7	17.6	17.6	17.5	17.4	17.3	17.2	17.2	17.1	17.0
26	16.9	16.9	16.8	16.7	16.6	16.6	16.5	16.4	16.4	16.3
27	16.2	16.1	16.1	16.0	15.9	15.9	15.8	15.7	15.7	15.6
28	15.5	15.5	15.4	15.3	15.3	15.2	15.2	15.1	15.0	15.0
29	14.9	14.8	14.8	14.7	14.7	14.6	14.5	14.5	14.4	14.4
30	14.3	14.3	14.2	14.1	14.1	14.0	14.0	13.9	13.9	13.8
31	13.8	13.7	13.6	13.6	13.5	13.5	13.4	13.4	13.3	13.3
32	13.2	13.2	13.1	13.1	13.0	13.0	12.9	12.9	12.8	12.8
33	12.7	12.7	12.6	12.6	12.5	12.5	12.4	12.4	12.3	12.3
34	12.3	12.2	12.2	12.1	12.1	12.0	12.0	11.9	11.9	11.8
35	11.8	11.8	11.7	11.7	11.6	11.6	11.5	11.5	11.5	11.4
36	11.4	11.3	11.3	11.2	11.2	11.2	11.1	11.1	11.0	11.0
37	11.0	10.9	10.9	10.8	10.8	10.8	10.7	10.7	10.7	10.6
38	10.6	10.5	10.5	10.5	10.4	10.4	10.4	10.3	10.3	10.2
39	10.2	10.2	10.1	10.1	10.1	10.0	10.0	10.0	9.9	9.9
40	9.8	9.8	9.8	9.7	9.7	9.7	9.6	9.6	9.6	9.5
41	9.5	9.5	9.4	9.4	9.4	9.3	9.3	9.3	9.2	9.2
42	9.2	9.1	9.1	9.1	9.1	9.0	9.0	9.0	8.9	8.9
43	8.9	8.8	8.8	8.8	8.7	8.7	8.7	8.6	8.6	8.6
44	8.6	8.5	8.6	8.5	8.4	8.4	8.4	8.4	8.3	8.3
45	8.3	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.0	8.0
46	8.0	8.0	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8
47	7.7	7.7	7.7	7.6	7.6	7.6	7.5	7.5	7.5	7.5
48	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.2	7.2
49	7.2	7.2	7.1	7.1	7.1	7.1	7.0	7.0	7.0	7.0

Table III. Wind Speed Table for Low Level Winds: Pilot Balloon Technique—Continued
(Argument for entry is vertical angle to nearest tenth degree.)

Degrees	Elevation Angle of Balloon in Degrees and Tenths of a Degree									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Table									
	Wind speed (miles per hour)									
50	6.9	6.9	6.9	6.9	6.8	6.8	6.8	6.8	6.7	6.7
51	6.7	6.7	6.6	6.7	6.6	6.6	6.6	6.5	6.5	6.5
52	6.5	6.4	6.4	6.4	6.3	6.3	6.3	6.3	6.3	6.3
53	6.2	6.2	6.2	6.2	6.1	6.1	6.1	6.1	6.1	6.0
54	6.0	6.0	6.0	5.9	5.9	5.9	5.9	5.9	5.8	5.8
55	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.6	5.6	5.6
56	5.6	5.6	5.5	5.5	5.5	5.5	5.5	5.4	5.4	5.4
57	5.4	5.3	5.3	5.3	5.3	5.3	5.2	5.2	5.2	5.2
58	5.2	5.1	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0
59	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.8	4.8	4.8
60	4.8	4.8	4.7	4.7	4.7	4.7	4.7	4.6	4.6	4.6
61	4.6	4.6	4.5	4.5	4.5	4.5	4.5	4.5	4.4	4.4
62	4.4	4.4	4.4	4.3	4.3	4.3	4.3	4.3	4.2	4.2
63	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.1
64	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.9
65	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.7	3.7	3.7
66	3.7	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.5	3.5
67	3.5	3.5	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4
68	3.3	3.3	3.3	3.3	3.3	3.3	3.2	3.2	3.2	3.2
69	3.2	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.0	3.0
70	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9
71	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.7	2.7	2.7
72	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.5
73	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4
74	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2
75	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1
76	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.9
77	1.9	1.9	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8
78	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6
79	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5
80	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3
81	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2
82	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0
83	1.0	1.0	1.0	1.0	1.0	.9	.9	.9	.9	.9
84	.9	.9	.8	.8	.8	.8	.8	.8	.8	.7
85	.7	.7	.7	.7	.7	.6	.6	.6	.6	.6
86	.6	.6	.6	.5	.5	.5	.5	.5	.5	.5
87	.4	.4	.4	.4	.4	.4	.4	.3	.3	.3
88	.3	.3	.3	.3	.2	.2	.2	.2	.2	.2
89	.1	.1	.1	.1	.1	.1	.1	.0	.0	.0

Table IV. Wind Correction Components for a One Mile Per Hour Wind: Pilot Balloon Technique

Degrees	Range wind	Cross wind*	Degrees	Degrees	Range wind	Cross wind*	Degrees
0	T 1.00	R .00 L	360	55	T .57	R .82 L	305
1	T 1.00	R .02 L	359	56	T .56	R .83 L	304
2	T 1.00	R .03 L	358	57	T .54	R .84 L	303
3	T 1.00	R .05 L	357	58	T .53	R .85 L	302
4	T 1.00	R .07 L	356	59	T .52	R .86 L	301
5	T 1.00	R .09 L	355	60	T .50	R .86 L	300
6	T .99	R .10 L	354	61	T .48	R .87 L	299
7	T .99	R .12 L	353	62	T .47	R .88 L	298
8	T .99	R .14 L	352	63	T .45	R .89 L	297
9	T .99	R .16 L	351	64	T .44	R .90 L	296
10	T .98	R .17 L	350	65	T .42	R .91 L	295
11	T .98	R .19 L	349	66	T .41	R .91 L	294
12	T .98	R .21 L	348	67	T .39	R .92 L	293
13	T .97	R .22 L	347	68	T .37	R .93 L	292
14	T .97	R .24 L	346	69	T .36	R .93 L	291
15	T .96	R .26 L	345	70	T .34	R .94 L	290
16	T .96	R .28 L	344	71	T .33	R .95 L	289
17	T .96	R .29 L	343	72	T .31	R .95 L	288
18	T .95	R .31 L	342	73	T .29	R .96 L	287
19	T .95	R .33 L	341	74	T .28	R .96 L	286
20	T .94	R .34 L	340	75	T .26	R .97 L	285
21	T .93	R .36 L	339	76	T .24	R .97 L	284
22	T .93	R .37 L	338	77	T .22	R .97 L	283
23	T .92	R .39 L	337	78	T .21	R .98 L	282
24	T .91	R .41 L	336	79	T .19	R .98 L	281
25	T .91	R .42 L	335	80	T .17	R .98 L	280
26	T .90	R .44 L	334	81	T .16	R .99 L	279
27	T .89	R .45 L	333	82	T .14	R .99 L	278
28	T .88	R .47 L	332	83	T .12	R .99 L	277
29	T .87	R .48 L	331	84	T .10	R .99 L	276
30	T .87	R .50 L	330	85	T .09	R 1.00 L	275
31	T .86	R .52 L	329	86	T .07	R 1.00 L	274
32	T .85	R .53 L	328	87	T .05	R 1.00 L	273
33	T .84	R .54 L	327	88	T .03	R 1.00 L	272
34	T .83	R .56 L	326	89	T .02	R 1.00 L	271
35	T .82	R .57 L	325	90	T .00	R 1.00 L	270
36	T .81	R .59 L	325	91	H .02	R 1.00 L	269
37	T .80	R .60 L	323	92	H .03	R 1.00 L	268
38	T .79	R .62 L	322	93	H .05	R 1.00 L	267
39	T .78	R .63 L	321	94	H .07	R 1.00 L	266
40	T .77	R .64 L	320	95	H .09	R 1.00 L	265
41	T .75	R .66 L	319	96	H .10	R .99 L	264
42	T .74	R .67 L	318	97	H .12	R .99 L	263
43	T .73	R .68 L	317	98	H .14	R .99 L	262
44	T .72	R .69 L	316	99	H .16	R .99 L	261
45	T .71	R .71 L	315	100	H .17	R .98 L	260
46	T .69	R .72 L	314	101	H .19	R .98 L	259
47	T .68	R .73 L	313	102	H .21	R .98 L	258
48	T .67	R .74 L	312	103	H .22	R .97 L	257
49	T .66	R .75 L	311	104	H .24	R .97 L	256
50	T .64	R .77 L	310	105	H .26	R .97 L	255
51	T .63	R .78 L	309	106	H .28	R .96 L	254
52	T .62	R .79 L	308	107	H .29	R .96 L	253
53	T .60	R .80 L	307	108	H .31	R .95 L	252
54	T .59	R .81 L	306	109	H .33	R .95 L	251

Note. When entering the table from the left (right), use the letter preceding (following) the correction component.

Table IV. Wind Correction Components for a One Mile Per Hour Wind: Pilot Balloon Technique—Continued

Degrees	Range wind	Cross wind*	Degrees	Degrees	Range wind	Cross wind*	Degrees
110	H .34	R .94 L	250	146	H .83	R .56 L	214
111	H .36	R .93 L	249	147	H .84	R .54 L	213
112	H .37	R .93 L	248	148	H .85	R .53 L	212
113	H .39	R .92 L	247	149	H .86	R .52 L	211
114	H .41	R .91 L	246	150	H .87	R .50 L	210
115	H .42	R .91 L	245	151	H .87	R .48 L	209
116	H .44	R .90 L	244	152	H .88	R .47 L	208
117	H .45	R .89 L	243	153	H .89	R .45 L	207
118	H .47	R .88 L	242	154	H .90	R .44 L	206
119	H .48	R .87 L	241	155	H .91	R .42 L	205
120	H .50	R .87 L	240	156	H .91	R .41 L	204
121	H .52	R .86 L	239	157	H .92	R .39 L	203
122	H .53	R .85 L	238	158	H .93	R .37 L	202
123	H .54	R .84 L	237	159	H .93	R .36 L	201
124	H .56	R .83 L	236	160	H .94	R .34 L	200
125	H .57	R .82 L	235	161	H .95	R .33 L	199
126	H .59	R .81 L	234	162	H .95	R .31 L	198
127	H .60	R .80 L	233	163	H .96	R .29 L	197
128	H .62	R .79 L	232	164	H .96	R .28 L	196
129	H .63	R .78 L	231	165	H .97	R .26 L	195
130	H .64	R .77 L	230	166	H .97	R .24 L	194
131	H .66	R .75 L	229	167	H .97	R .22 L	193
132	H .67	R .74 L	228	168	H .98	R .21 L	192
133	H .68	R .73 L	227	169	H .98	R .19 L	191
134	H .69	R .72 L	226	170	H .98	R .17 L	190
135	H .71	R .71 L	225	171	H .99	R .16 L	189
136	H .72	R .69 L	224	172	H .99	R .14 L	188
137	H .73	R .68 L	223	173	H .99	R .12 L	187
138	H .74	R .67 L	222	174	H .99	R .10 L	186
139	H .75	R .66 L	221	175	H 1.00	R .09 L	185
140	H .77	R .64 L	220	176	H 1.00	R .07 L	184
141	H .78	R .63 L	219	177	H 1.00	R .05 L	183
142	H .79	R .62 L	218	178	H 1.00	R .03 L	182
143	H .80	R .60 L	217	179	H 1.00	R .02 L	181
144	H .81	R .59 L	216	180	H 1.00	R .00 L	180
145	H .82	R .57 L	215				

By Order of the Secretary of the Army:

HAROLD K. JOHNSON,
General, United States Army,
Chief of Staff.

Official:

J. C. LAMBERT,
Major General, United States Army,
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DCSPER (2)
ACSI (2)
DCSLOG (2)
DCSOPS (2)
CORC (2)
CRD (1)
CINFO (1)
TIG (1)
USACDCARTYA (3)
USCONARC (5)
Armies (5)
Corps (3)
Div (5)
FA Bde (5)
FA Gp (3)
USATC FA (25)
USMA (2)
Br Svc Sch (1)
PMS Sr Div Units (FA) (1)
MAAG (2)
Units org under fol TOE:
6–175 (10)
6–228 (5)
6–525 (10)
6–565 (10)

NG: Div (1); Div Arty (1); Corps Arty (1); FA Gp (1); TOE: 6–176 (2); 6–177 (3).
USAR: Units—same as Active Army except allowance is one copy to each unit.
For explanation of abbreviations used, see AR 320–50.

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